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U.S. Army
Environmental
Center

REMEDIAL INVESTIGATION/FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT
BARABOO, WISCONSIN

FINAL
FEASIBILITY STUDY
DATA ITEM A009

VOLUME II OF III
TABLES AND FIGURES

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U.S. ARMY ENVIRONMENTAL CENTER
ABERDEEN PROVING GROUND, MARYLAND

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VOLUME II OF III
TABLES AND FIGURES

FINAL FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

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BADGER ARMY AMMUNITION PLANT

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Table ES-1
Summary of Contamination Assessment through Remedial Alternatives Screening Propellant Burning Ground

Feasibility Study
Badger Army Ammunition Plant

RI/FS Component	Contaminated Media at the Propellant Burning Ground		
	Surface Soil	Subsurface Soil	Groundwater
Identification of Contaminants of Concern	• VOCs • SVOCs • Explosives • Inorganics	• VOCs • SVOCs • Explosives • Inorganics	• VOCs • SVOCs • Explosives • Inorganics
Risk Assessment Results	• 24DNT, CPAH, AS and PB are a threat to humans. • AS, CR, PB, SE, and ZN are a threat to groundwater. • PB, CU, HG, SE, and ZN are a threat to terrestrial receptors.	• 24DNT, 26DNT, CPAH, C6H6; AS, and PB are a threat to humans. • 24DNT, 26DNT, TRCLE, AS, CR, PB, SE, and ZN are a threat to groundwater.	• CCL4, NIT, 26DNT, CHCL3, TRCLE, and HG exceed WESs. • CR, PB, 111TCE, and CD exceed WPALs. • BE exceeds the interim WPAL and NNDPA exceeds the interim WES. • MN and SO4 exceed public welfare standards. • NA exceeds the reporting level.
Remedial Action Objectives	• Prevent unacceptable concentrations of 24DNT, CPAH, AS, and PB from becoming available to humans. • Prevent unacceptable concentrations of CU, HG, PB, SE, and ZN from becoming available to ecological receptors. • Prevent AS, CR, PB, SE, and ZN from degrading groundwater quality. • Prevent unacceptable concentrations of DNTs in WP-2 and WP-3 from becoming available to human or ecological receptors.	• Prevent unacceptable concentrations of 24DNT, 26DNT, CPAH, C6H6, AS, and PB from becoming available to humans. • Prevent 24DNT, 26DNT, TRCLE, AS, CR, PB, SE, and ZN from degrading groundwater quality.	• Prevent further migration of contaminated groundwater. • Reduce CCL4, 26DNT, CHCL3, TRCLE, 111TCE, CR, PB, CD, and HG to interim WPALs. • Reduce BE and NNDPA to interim WPALs. • Reduce MN and SO4 to public welfare standards.

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TABLE ES-1
SUMMARY OF CONTAMINATION ASSESSMENT
THROUGH REMEDIAL ALTERNATIVES SCREENING
PROPELLANT BURNING GROUND

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

RI/FS COMPONENT	CONTAMINATED MEDIA AT THE PROPELLANT BURNING GROUND		
	SURFACE SOIL	SUBSURFACE SOIL	GROUNDWATER
Remedial Technologies Retained After Screening	• Soil Cover • Off-Site Landfill • Stabilization/Solidification • Soil Washing • In Situ Stabilization/ Solidification	1949 Pit and Old Landfill: • Capping • Off-Site Landfill Waste Pits: • Capping • Off-Site Landfill • Slurry Wall • Soil Washing • On- and Off-Site Incineration • In Situ Vacuum Extraction • In Situ Stabilization/ Solidification • Soil Flushing • Chemical-Biological • Bioventing • Composting	• Groundwater Extraction Wells • UV/Oxidation • Air Stripping • UV/Reduction • Carbon Adsorption • Resin Adsorption • In-Situ Biological • Surface Water Discharge
Remedial Alternatives Developed	• Minimal Action • Soil Cover • Off-Site Landfill • Stabilization/Solidification and Soil Cover • Soil Washing • Modified In Situ Stabilization/Solidification and Soil Cover	1949 Pit and Old Landfill: • Minimal Action • Capping • Off-Site Landfill Waste Pits: • Minimal Action • Capping • Off-Site Landfill and Capping • On-Site Incineration and Capping • Off-Site Incineration and Capping • In-Situ Vacuum Extraction, Composting, and Capping • In Situ Treatment • In Situ Vacuum Extraction and Bioventing • On-Site Incineration • In Situ Vacuum Extraction, Soil Washing, and Composting • In Situ Stabilization/ Solidification and Soil Cover	• Minimal Action • Existing Conditions • IRM and UV/Oxidation, Air Stripping • IRM and Air Stripping, Carbon Adsorption, Discharge • IRM and Resin Adsorption • In-Situ Biological • IRM and UV/Reduction, Carbon Adsorption

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TABLE ES-1
SUMMARY OF CONTAMINATION ASSESSMENT THROUGH REMEDIAL ALTERNATIVES SCREENING PROPELLANT BURNING GROUND

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

RI/FS COMPONENT	CONTAMINATED MEDIA AT THE PROPELLANT BURNING GROUND		
	SURFACE SOIL	SUBSURFACE SOIL	GROUNDWATER
Remedial Alternatives Retained After Screening	• Minimal Action • Soil Cover • Modified In Situ Stabilization/Solidification and Soil Cover	1949 Pit and Old Landfill: • Minimal Action • Capping • Off-Site Landfill Waste Pits: • Minimal Action • On-Site Incineration and Capping • Composting and Capping • In Situ Vacuum Extraction, Composting, and Capping • In Situ Treatment • On-Site Incineration • In Situ Vacuum Extraction, Soil Washing, and Composting	• Minimal Action • IRM and Carbon Adsorption • IRM and Air Stripping, Carbon Adsorption • IRM and Resin Adsorption • IRM and UV/Reduction, Carbon Adsorption

Notes:

IRM = Interim Remedial Measure
SVOCs = semivolatile organic compound
UV = ultraviolet
VOCs = volatile organic compound

Full compound names are identified in the USAEC Chemical Code List located behind the Glossary of Acronyms.

(continued)

TABLE ES-1
SUMMARY OF CONTAMINATION ASSESSMENT
THROUGH REMEDIAL ALTERNATIVES SCREENING
DETERRENT BURNING GROUND

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

RI/FS COMPONENT	CONTAMINATED MEDIA AT DETERRENT BURNING GROUND	
	SUBSURFACE SOIL	GROUNDWATER
Identification of Contaminants of Concern	• VOCs • SVOCs • Explosives • Inorganics	• VOCs • SVOCs • Inorganics • Explosives
Risk Assessment Results	• 24DNT, 26DNT, NNDPA, and AS are a threat to humans. • 24DNT, 26DNT, AS, and CR are a potential threat to groundwater. • No ecological risk	• 26DNT, 112TCE, CR, HG, and NIT exceed MCLs or WESs. • CD, PB, and BA exceed WPALs • MN and SO4 exceed SDWA standards. • BE and NNDPA exceed interim WPALs. • No ecological risk.
Remedial Action Objectives	• Prevent concentrations of 24DNT, 26DNT, NNDPA, and AS which exceed clean-up standards for protection of human health from becoming available, either through incidental ingestion or inhalation to potential human receptors. • Prevent concentrations of 24DNT, 26DNT, AS, and CR which exceed cleanup standards for protection of groundwater from degrading groundwater quality.	• Prevent further contamination of elevated groundwater system. • Prevent exposure to concentrations of 26DNT, 112TCE, NIT, BA, CD, PB, CR, and HG exceeding their respective WPALs. • Prevent exposure of BE and NNDPA exceeding respective interim WPALs • Prevent exposure of MN and SO4 at levels exceeding SDWA levels.
Remedial Technologies Retained After Screening	• Soil Cover • Capping • Off-Site Landfill • On-site Incineration • Off-Site Incineration • Composting • Soil Washing	• Groundwater Extraction Wells • UV/Oxidation • Air Stripping • Carbon Adsorption • Resin Adsorption • UV/Reduction • Discharge to Surface Water

(continued)

TABLE ES-1
SUMMARY OF CONTAMINATION ASSESSMENT
THROUGH REMEDIAL ALTERNATIVES SCREENING
DETERRENT BURNING GROUND

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

RI/FS COMPONENT	CONTAMINATED MEDIA AT DETERRENT BURNING GROUND	
	SUBSURFACE SOIL	GROUNDWATER
Remedial Alternatives Developed	• Minimal Action • Capping • Off-Site Landfill • Soil Washing • Off-Site Incineration • Off-Site Incineration, Soil Washing • On-Site Incineration • Composting, Soil Cover	• Minimal Action • Groundwater Extraction, IRM and Carbon Adsorption • Groundwater Extraction, IRM and UV/Oxidation-Discharge • Groundwater Extraction, IRM and Air Stripping-Carbon Adsorption, Discharge • Groundwater Extraction, IRM and Resin Adsorption, Discharge • Groundwater Extraction, IRM and UV/Reduction - Carbon Adsorption, Discharge
Remedial Alternatives Retained After Screening	• Minimal Action • Capping • Soil Washing • On-Site Incineration • Composting	• Minimal Action • Groundwater Extraction, IRM and Carbon Adsorption • Groundwater Extraction, IRM and Air Stripping, Carbon Adsorption, Discharge • Groundwater Extraction, IRM and Resin Adsorption, Discharge • Groundwater Extraction, IRM and UV/Reduction - Carbon Adsorption, Discharge

(continued)

Table ES-1
Summary of Contamination Assessment through Remedial Alternatives Screening Nitroglycerine Pond/Rocket Paste Area

Feasibility Study
Badger Army Ammunition Plant

RI/FS Component	Contaminated Media at Nitroglycerine Pond/Rocket Paste Area		
	Surface Soil	Sediment	Surface Water
Identification of Contaminants of Concern	• SVOCs • Inorganics	• SVOCs • Inorganics	• Inorganics
Risk Assessment Results	• PB, 24DNT, 26DNT, CPAH, and NNDPA are a threat to humans. • PB, NG, HG, CR, NNDPA, 26DNT, and 24DNT all exceed acceptable ecological risk levels. • PB, CR, and 24DNT all exceed acceptable groundwater risk levels.	• CR, HG, PB all exceed acceptable ecological risk levels. • PB also a threat to humans. • CR and PB exceed acceptable groundwater risk levels. • Levels of SVOCs do not pose an unacceptable health risk.	• AL, HG, CR, CU, FE, MN, PB, and ZN all exceed acceptable ecological risk standards.
Remedial Action Objectives	• Prevent migration of contaminated soil by erosion. • Reduce exposure to PB, 24DNT, 26DNT, CPAH, and NNDPA concentration to acceptable risk levels for humans. • Reduce exposure to concentrations of PB, CR, HG, NG, 24DNT, 26DNT and NNDPA to acceptable risk levels for terrestrial organisms.	• Prevent migration of contaminated sediment into drainageways downgradient of ponds. • Prevent contaminants in sediment from contaminating surface water in ponds. • Reduce exposure of concentrations of CR, HG, and PB in sediments at the Nitroglycerine Pond to levels resulting in acceptable risk for aquatic and semiaquatic receptors.	• Reduce AL, HG, MN, PB, CR, CU, FE, and ZN concentrations to levels resulting in acceptable risk for aquatic and semiaquatic receptors.

(continued)

TABLE ES-1
SUMMARY OF CONTAMINATION ASSESSMENT
THROUGH REMEDIAL ALTERNATIVES SCREENING
NITROGLYCERINE POND/ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

RI/FS COMPONENT	CONTAMINATED MEDIA AT NITROGLYCERINE POND/ROCKET PASTE AREA		
	SURFACE SOIL	SEDIMENT	SURFACE WATER
Remedial Action Objectives	• Reduce exposure to PB, CR, and 24DNT to acceptable levels for groundwater.	• Reduce exposure to PB concentration in Rocket Paste Pond to acceptable risk level for humans. • Reduce exposure to CR and PB to acceptable levels for groundwater.	
Remedial Technologies Retained After Screening	• Soil Cover • Off-Site Landfill • On-Site Disposal • Solidification/ Stabilization • In-Situ Solidification/ Stabilization	• Soil Cover • On-Site Disposal • Off-Site Landfill • Solidification/ Stabilization • In-Situ Solidification/ Stabilization	• Precipitation • Ion Exchange • Microfiltration • Return water to surface water
Remedial Alternatives Developed	• Minimal Action • Soil Cover • Excavation/Solidification/On-Site Disposal • Excavation/Off-site Disposal • In-situ Solidification/ Stabilization	• Minimal Action • Soil Cover • Excavation/Solidification/On-Site Disposal • Excavation/Off-site Disposal • In-Situ Solidification/ Stabilization	• Minimal Action • Precipitation/ Microfiltration • Ion Exchange

(continued)

TABLE ES-1
SUMMARY OF CONTAMINATION ASSESSMENT
THROUGH REMEDIAL ALTERNATIVES SCREENING
NITROGLYCERINE POND/ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

RI/FS COMPONENT	CONTAMINATED MEDIA AT NITROGLYCERINE POND/ROCKET PASTE AREA		
	SURFACE SOIL	SEDIMENT	SURFACE WATER
Remedial Alternatives Retained After Screening	• Minimal Action • Soil Cover • Excavation/ Solidification/On-Site Disposal • Excavation/Off-site Disposal • In-situ solidification/ stabilization	• Minimal Action • Soil Cover • Excavation/Solidificati on/ On-Site Disposal • Excavation/Off-site Disposal • In-situ solidification/ stabilization	• Minimal Action • Precipitation/ Microfiltration • Ion Exchange

Note:

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

(continued)

TABLE ES-1
SUMMARY OF CONTAMINATION ASSESSMENT
THROUGH REMEDIAL ALTERNATIVES SCREENING
SETTLING PONDS AND SPOILS DISPOSAL AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

RI/FS COMPONENT	CONTAMINATED SOIL AT THE SETTLING PONDS AND SPOILS DISPOSAL AREA SURFACE SOILS
Identification of Contaminants of Concern	• SVOCs • Inorganics
Risk Assessment Results	• 24DNT, 26DNT, CPAH, PB, and ZN exceed human health and/or protection of groundwater criteria (as developed from proposed Chapter NR 720). • AL, DPA, DEP, NG, PB, SN, and ZN exceed acceptable ecological risk standards.
Remedial Action Objectives	• Prevent migration of contaminated soil by soil erosion. • Prevent the exposure of terrestrial receptors to surface soil at Final Creek and the Settling Ponds containing concentrations of PB (excluding Settling Pond 3) and SN that pose unacceptable risk. • Prevent the exposure to terrestrial receptors to surface soil containing concentrations of DEP (at Settling Ponds 1, 2, and 3) and DPA (at Final Creek and Settling Pond 1) that pose unacceptable risk. • Prevent the exposure of terrestrial receptors to surface soil at Settling Pond 4 containing concentrations of AL that pose unacceptable risk. • Prevent the exposure of terrestrial receptors to surface soil at the Spoils Disposal Sites containing concentrations of ZN and PB that pose unacceptable risk. • Prevent the exposure of terrestrial receptors to surface soil at Spoils Disposal Site 1 containing concentrations of DPA and NG that pose unacceptable risk. • Prevent the exposure of human receptors to soil at Final Creek and the Settling Ponds containing concentrations of 24DNT, 26DNT, and CPAH that pose unacceptable risk. • Prevent the exposure of human receptors to soil at the Spoils Disposal Sites containing concentrations of 24DNT that pose unacceptable risks. • Prevent concentrations of 24DNT and PB in soil at Final Creek and the Settling Ponds which exceed cleanup standards for protection of groundwater (developed from the proposed Chapter NR 720) from degrading groundwater quality in excess of WPALs. • Prevent concentrations of 24DNT, PB, and ZN in soil at the Spoils Disposal sites which exceed cleanup standards for protection of groundwater (developed from the proposed Chapter NR 720) from degrading groundwater quality in excess of WPALs.
Remedial Technologies Retained After Screening	• Soil Cover • Capping • Off-Site Landfill • Ex-Situ Stabilization/Solidification • In-Situ Stabilization/Solidification • Soil Washing

Table ES-1
Summary of Contamination Assessment through Remedial Alternatives Screening Settling Ponds and Spoils Disposal Area

Feasibility Study
Badger Army Ammunition Plant

RI/FS Component	Contaminated Soil at the Settling Ponds and Spoils Disposal Area Surface Soils
Remedial Alternatives Developed	• Minimal Action • Soil Cover • Capping • Off-Site Landfill • Soil Washing • Ex-situ Stabilization/Solidification • Modified In-Situ Stabilization/Solidification, Soil Cover • Ex-situ Stabilization/Solidification, Off-Site Landfill
Remedial Alternatives Retained After Screening	• Minimal Action • Capping • Modified In Situ Stabilization/Solidification, Soil Cover

(continued)

TABLE ES-1
SUMMARY OF CONTAMINATION ASSESSMENT
THROUGH REMEDIAL ALTERNATIVES SCREENING
SOUTHERN OFF-POST AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

RI/FS Component	Contaminated Media at the Southern Off-Post Area: Groundwater
Identification of Contaminants of Concern	• VOCs • Inorganics
Risk Assessment Results	• CCL4 exceeds MCL, WES, and WPAL • CHCL3, CD, PB, and TRCLE exceed WPALs but are below MCL and WES • MN exceeds secondary drinking water standards, and public welfare standards
Remedial Action Objective	• Prevent concentrations of CCL4, CHCL3, TRCLE, CD, MN, and PB in groundwater which exceed WPALs from becoming available to potential human receptors
Remedial Technologies Retained After Screening	• Groundwater monitoring • Institutional controls • Groundwater extraction wells • Airstripping • Carbon adsorption • Surface Water Discharge
Remedial Alternatives Developed	• Minimal Action • Airstripping • Carbon adsorption
Remedial Alternatives Retained After Screening	• Minimal Action • Airstripping • Carbon adsorption

Notes:

WES = Wisconsin Enforcement Standard
WPAL = Wisconsin Preventative Action Limit

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

TABLE ES-2
COMPARATIVE SUMMARY OF ALTERNATIVES
PROPELLANT BURNING GROUND SURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative PBG-SS1: Minimal Action	Reduces potential for human exposure to contaminated soil. Not protective of ecological receptors or groundwater.	No chemical-specific ARARs. Although this alternative could meet the intent of the proposed Chapter NR 720 standards for protection of human health, it would not meet the intent of the proposed standards for protection of groundwater.	If managed properly, residual risk to human receptors would be minor. No reduction in residual risk to ecological receptors or threat of groundwater contamination.	Contamination is not treated or destroyed; no reduction of toxicity, mobility, or volume of contaminants.	No adverse community or environmental impacts during implementation.	No implementability concerns.	Total Present Worth: <u>$277,000</u> Capital Cost: $108,000 Annual O&M: $11,000 (30 yrs)
Alternative PBG-SS2: Soil Cover	Achieves remedial action objectives for protection of human health and ecological receptors. Not protective of groundwater.	No chemical-specific ARARs. Although this alternative could meet the intent of the proposed Chapter NR 720 standards for protection of human health, it would not meet the intent of the proposed standards for protection of groundwater.	If managed properly, residual risk to human and ecological receptors would be negligible. No reduction in threat of groundwater contamination.	No reduction of toxicity, mobility, or volume of contaminants. However, mobilizing influences (e.g., soil erosion) would be reduced.	No adverse impacts to the community and only minimal impact (if general health and safety practices are followed) to workers during implementation. Minor impact to the environment.	No implementability concerns. Soil covers are easily constructed and maintained.	Total Present Worth: <u>$1,985,000</u> Capital Cost: $1,385,000 Annual O&M: $39,000 (30 yrs)
Modified Alternative PBG-SS6: In Situ S/S and Soil Cover	Achieves remedial action objectives for protection of human health, groundwater, and ecological receptors.	No chemical-specific ARARs. This alternative could meet the intent of the proposed Chapter NR 720 standards for protection of human health and groundwater.	Residual risk to human and ecological receptors would be negligible and the threat of groundwater contamination would be removed.	No reduction of toxicity. Potential mobility would be reduced by S/S. Volume would increase by up to 50 percent.	No adverse impacts to the community and only minimal impact (if general health and safety practices are followed) to workers during implementation. Minor impact to the environment.	Significant implementability concerns. In situ S/S of surface soils is a developing technology and extensive treatability testing is required.	Total Present Worth: <u>$7,337,000</u> Capital Cost: $6,860,000 Annual O&M: $31,000 (30 yrs)

(continued)

TABLE ES-2
COMPARATIVE SUMMARY OF SUBSURFACE SOIL ALTERNATIVES
PROPELLANT BURNING GROUND SUBSURFACE SOIL

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative PBG-SB1: Minimal Action	Reduces potential for human exposure to contaminated soil. Not protective of groundwater.	No chemical-specific ARARs. This alternative would not meet the intent of the proposed Chapter NR 720 standards for protection of human health and groundwater.	If managed properly, residual risk to human receptors would be minor. No reduction in the threat of ground-water contamination.	Contamination is not treated or destroyed; no reduction of toxicity, mobility, or volume of contaminants.	No adverse community or environmental impacts during implementation.	No implementability concerns.	Total Present Worth: $118,000 Capital Cost: $10,000 Annual O&M: $7,000 (30 yrs)
Alternative PBG-SB2: Capping	High potential for achieving remedial action objectives for protection of human health and groundwater.	No chemical-specific ARARs. This alternative could meet the intent of the proposed Chapter NR 720 standards for protection of human health and groundwater.	If managed properly, residual risk to human receptors and the threat of groundwater contamination would be negligible.	No reduction of toxicity, mobility, or volume of contaminants. However, mobilizing influences (e.g., infiltration of precipitation) would be reduced.	No adverse impacts to the community and only minimal (if general health and safety practices are followed) to workers during implemen-tation.	No implementability concerns. RCRA caps are easily constructed and maintained.	Total Present Worth: $1,360,000 Capital Cost: $1,252,000 Annual O&M: $7,000 (30 yrs)
Alternative PBG-SB3: Off-Site Landfill	Achieves remedial action objectives for protection of human health and groundwater.	No chemical-specific ARARs. This alternative would comply with pathway-specific numeric standards derived from the proposed Chapter NR 720.	No residual risk at Landfill 1 and the 1949 Pit. If managed properly, residual risk at receiving off-site landfill would be negligible.	S/S may occur at the off-site landfill prior to disposal. S/S would not reduce toxicity but would reduce potential mobility. Volume would increase by up to 50 percent.	No adverse impacts to the community and only minimal (if general health and safety practices are followed) to workers during implemen-tation.	No implementability concerns. Excavation and disposal in an off-site landfill would be easily implemented.	Total Present Worth: $2,843,000 Capital Cost: $2,843,000 Annual O&M: $0

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TABLE ES-2
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative PBG-WP1: Minimal Action	Reduces potential for human exposure to contaminated soil. Not protective of groundwater.	No chemical-specific ARARs. This alternative would not meet the intent of the proposed Chapter NR 720 standards for protection of human health and groundwater.	If managed properly, residual risk to human receptors wold be minor. No reduction in the threat of groundwater contamination.	Contamination is not treated or destroyed; no reduction of toxicity, mobility, or volume of contaminants.	No adverse community or environmental impacts during implementation.	No implementability concerns.	Total Present Worth: $118,000 Capital Cost: $10,000 Annual O&M: $7,000 (30 yrs)
Alternative PBG-WP4: On-Site Incineration and Capping	Achieves remedial action objectives for protection of human health. Large quantity of contaminants would remain in waste pit soils. Caps would not provide total containment needed to protect groundwater.	No chemical-specific ARARs. This alternative could meet the intent of the proposed Chapter NR 720 standards for protection of human health but not groundwater.	Residual risk to human receptors would be negligible but the large quantity of contaminants and the inherent mobility of VOCs would pose a significant long-term threat to groundwater quality.	Incinerator destruction and removal efficiency would be at least 99.9999 percent. Caps would limit natural mobilizing influences on remaining contaminants.	Because the incinerator would be operating in a isolated location, risks associated with emissions are expected to be minor. Reactive risk associated with excavating/handling DNT-contaminated soil.	No implementability concerns. Incineration is a proven technology for explosive-contaminated soil. Caps are easily constructed and maintained.	Total Present Worth: $6,793,000 Capital Cost: $6,685,000 Closure O&M: $7,000/yr (30 yrs)
Alternative PBG-WP5: Composting and Capping	Achieves remedial action objective for protection of human health. Large quantity of contaminants would remain in waste pit soils. Caps would not provide total containment needed to protect groundwater.	No chemical-specific ARARs. This alternative could meet the intent of the proposed Chapter NR 720 standards for protection of human health but not groundwater.	Residual risk to human receptors would be negligible but the large quantity of contaminants and the inherent mobility of VOCs would pose a significant long-term threat to groundwater quality.	Bacterial mutagenicity and aquatic toxicity reduced by 88 to 98 percent. Caps would limit natural mobilizing influences on remaining contaminants.	Remote location of composting site would provide for adequate dispersal of odors and airborne contaminants. Reactive risk associated with excavating/handling DNT-contaminated soil.	Minor implementability concerns. While general technical feasibility of composting has been demonstrated at similar sites, treatability studies would be required prior to full-scale design and construction.	Total Present Worth: $5,360,000 Capital Cost: $4,219,000 Composting O&M: $1,085,000 1 yr Closure O&M: $7,000/yr (30 yrs)

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TABLE ES-2
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative PBG-WP7: In Situ Vacuum Extraction, Composting, and Capping	Achieves remedial action objective for protection of human health. Although a large quantity of contaminants would remain in waste pit soils, in situ vacuum extraction would have removed the more mobile VOCs. Caps may provide total containment of remaining SVOCs and protect groundwater.	No chemical-specific ARARs. This alternative could possibly meet either numeric standards or performance standards for protection of human health and groundwater per the proposed Chapter NR 720 standards.	Residual risk to human receptors would be negligible. Large quantities of contaminants would pose a significant long-term threat to groundwater quality. However, removal of VOCs could result in reduced threat to groundwater quality.	VOC removal efficiencies of up to 99 percent are possible with in situ vacuum extraction. Composting reduces bacterial mutagenicity and aquatic toxicity by 88 to 98 percent.	Remote location of composting site would provide for adequate dispersal of odors. Reactive risk associated with excavating/handling DNT-contaminated soil.	Minor implementability concerns. While general technical feasibility of in situ vacuum extraction and composting has been demonstrated, treatability studies would be required prior to full-scale design and construction.	Total Present Worth: <u>$5,585,000</u> Capital Cost: $4,444,000 Composting O&M: $1,085,000/ 1 yr Closure O&M: $7,000/yr (30 yrs)
Alternative PBG-WP8: In Situ Treatment	Achieves remedial action objectives for protection of human health and groundwater.	No chemical-specific ARARs. This alternative would comply with pathway-specific numeric standards derived from the proposed Chapter NR 720.	No residual risk.	<u>Soil Flushing</u> Existing IRM facility would achieve removal efficiency greater than 99 percent. Off-site destruction of contaminants in spent carbon. <u>Chemical-Biological</u> Chemical oxidation and biodegradation would result in complete contaminant degradation.	<u>Soil Flushing</u> Because there would be no excavation of contaminated soil and treatment would occur in the IRM facility, overall risk would be minimal. <u>Chemical-Biological</u> VOCs would be contained during soil mixing. Reactive risk associated with mixing DNT-contaminated soil may be exacerbated by addition of hydrogen peroxide.	Potentially significant implementability concerns. In situ soil flushing and chemical-biological have not been applied to explosive-contaminated soil or to remediation of any site at this scale. Extensive treatability testing is required.	Soil Flushing Total Present Worth: <u>$15,320,000</u> Capital Cost: $12,691,000 O&M: $349,000/yr (11 yrs) Chemical-Biological Total Present Worth: <u>$24,274,000</u> Capital Cost: $11,987,000 O&M: $10,754,000/ yr (16 months)

(continued)

Table ES-2
Comparative Summary of Remedial Alternatives
Propellant Burning Ground Waste Pits

Feasibility Study
Badger Army Ammunition Plant

Alternative	Overall Protection	Compliance with ARARs	Effectiveness: Long-Term	Reduction in Toxicity, Mobility, and Volume	Effectiveness: Short-Term	Implementability	Cost
Alternative PBG-WP10: On-Site Incineration	Achieves remedial action objectives for protection of human health and groundwater.	No chemical-specific ARARs for soil. However, destroying soil contaminants would eliminate generation of leachate. This alternative would comply with pathway-specific numeric standards derived from the proposed Chapter NR 720.	No residual risk.	Incinerator destruction and removal efficiency would be at least 99.9999 percent.	Because the incinerator would be operating in an isolated location, risks associated with emissions are expected to be minor. Reactive risk associated with excavating/handling DNT-contaminated soil.	No implementability concerns. Diaphragm wall technology has been demonstrated in large-scale civil projects. Incine-ration is a proven technology for explosive-con-taminated soil.	Total Present Worth: $49,582,000 Capital Cost: $20,941,000 Annual O&M: $21,307,000 (1.5 yrs)
Alternative PBG-WP11: In Situ Vacuum Extraction, Soil Washing, and Composting	Achieves remedial action objectives for protection of human health and groundwater.	No chemical-specific ARARs. This alternative would comply with pathway-specific numeric standards derived from the proposed Chapter NR 720.	No residual risk	VOC removal efficiencies of up to 99 percent are possible with in situ vacuum extraction. Soil washing is capable of volume reductions of approximately 90 percent. Composting reduces bacterial mutagenicity and aquatic toxicity by 88 to 98 percent.	Remote location of composting site would provide for adequate dispersal of odors. Reactive risk associated with excavating/ handling DNT-contaminated soil.	Minor implement-ability concerns. While general technical feasibility of insitu vacuum extraction, soil washing, and com-posting has been demonstrated. Treatability studies would be required prior to full-scale design and construction.	Total Present Worth: $38,309,000 Capital Cost: $35,006,000 Annual O&M: $1,052,000 (3.5 yrs)

Notes:

ARARs = Applicable or Relevant and Appropriate Requirements
IRM = Interim Remedial Measures
VOCs = volatile organic compounds

TABLE ES-2
COMPARATIVE SUMMARY OF GROUNDWATER ALTERNATIVES
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative PBG-GW1: Minimal Action	Not protective of human health. Groundwater contaminant concentrations may increase and plume's areal extent would expand.	Would not achieve WPALs. Location-specific and action-specific ARARs do not apply.	Not applicable because remedial action objectives are not achieved.	Contamination is not treated or destroyed; no reduction of toxicity, mobility, or volume of contaminants.	No adverse community or environmental impacts during implementation	No implementability concerns.	Total Present Worth: $7,442,000 Capital Cost: $10,000 Annual O&M: $387,000
Alternative PBG-GW2: IRM and Carbon Adsorption	Achieves remedial action objectives for human receptors downgradient of the Contaminated Waste Area.	Would achieve WPALs in aquifer downgradient of source control wells. Capable of achieving WPDES permit limits.	Residual risk would be minimal downgradient of source control wells. Inherent residual risk unless source is remediated.	Removal efficiency greater than 99%. Approximately 360,000 lbs of spent carbon generated annually. Off-site destruction of contaminants.	No adverse impacts to community. Potentially adverse impacts to environment during construction of extraction system.	No implementability concerns. Technologies have been proven full-scale. No problems expected permitting discharge.	Total Present Worth: $35,040,000 Capital Cost: $6,569,000 Annual O&M: $1,485,000
Alternative PBG-GW4: IRM and Air Stripping - Carbon Adsorption	Achieves remedial action objectives for human receptors downgradient of the Contaminated Waste Area.	Would achieve WPALs in aquifer downgradient of source control wells. Capable of achieving WPDES and air permits limits.	Residual risk would be minimal downgradient of source control wells. Inherent residual risk unless source is remediated.	Removal efficiency greater than 99%. Approximately 186,000 lbs of spent carbon generated annually. Off-site destruction of contaminants.	No adverse impacts to community. Potentially adverse impacts to environment during construction of extraction system.	No implementability concerns. Technologies have been proven full-scale. No problems expected permitting discharge or air emissions.	Total Present Worth: $35,563,000 Capital Cost: $7,303,000 Annual O&M: $1,474,000
Alternative PBG-GW5: IRM and Resin Adsorption	Achieves remedial action objectives for human receptors downgradient of the Contaminated Waste Area.	Would achieve WPALs in aquifer downgradient of source control wells. Capable of achieving WPDES permit limits.	Residual risk would be minimal downgradient of source control wells. Inherent residual risk unless source is remediated.	Removal efficiency greater than 99%. Approximately 350 lbs of organic phase and 120,000 lbs of spent carbon generated annually. Off-site destruction of contaminants.	No adverse impacts to community. Potentially adverse impacts to environment during construction of extraction system.	Significant implementability concerns. Resin technology has not been proven full-scale and extensive treatability testing would be required. No problems expected permitting discharge.	Total Present Worth: $35,564,000 Capital Cost: $9,047,000 Annual O&M: $1,383,000
Alternative PBG-GW7: IRM and UV Reduction - Carbon Adsorption	Achieves remedial action objectives for human receptors downgradient of the Contaminated Waste Area.	Would achieve WPALs in aquifer downgradient of source control wells. Capable of achieving WPDES permit limits.	Residual risk would be minimal downgradient of source control wells. Inherent residual risk unless source is remediated.	Destruction and removal efficiency greater than 99%. Approximately 120,000 lbs of spent carbon generated annually. On-site and off-site destruction of contaminants.	No adverse impacts to community. Potentially adverse impacts to environment during construction of extraction system.	Minor implementability concerns. Treatability studies required to adapt UV reduction to the wastestream. No problems expected permitting discharge.	Total Present Worth: $40,069,000 Capital Cost: $8,446,000 Annual O&M: $2,056,000

(continued)

TABLE ES-2
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative DBG-SB1: Minimal Action	Protective of human health, however, contaminated subsurface soils will remain on site and pose a risk to construction workers doing intrusive work and groundwater.	No action would be taken at the site, therefore location- and action-specific ARARs would not apply. Proposed Chapter NR 720 clean-up standards would not be met.	Would be capable of protecting human health through institutional controls.	Contamination is not treated or destroyed; no reduction in toxicity, mobility, or volume.	No implementation, therefore no adverse community or environmental impacts during implementation.	No implementability concerns.	Total Present Worth: $118,000 Capital Costs: $10,000 Annual O&M Costs: $108,000
Alternative DBG-SB2: Capping	Protective of human health and ground-water; however, subsurface soils will remain on site and pose a risk if the integrity of the cap is violated.	This alternative could meet the intent of NR 720 clean-up standards. Location-specific ARARs for landfills would apply. Action-specific ARARs would be addressed.	Would be capable of protecting human health through institutional controls. Would be capable of protecting groundwater.	Contamination is not treated or destroyed; no reduction in toxicity, mobility, or volume.	Fugitive dust from construction site could result in risk to the community.	Landfill contractor must use employees who have current OSHA site worker protection training.	Total Present Worth: $642,000 Capital Costs: $534,000 Annual O&M Costs: $108,000
Alternative DBG-SB4: Soil Washing	Protective of human health because soils will be excavated and treated to below RGs.	Location-specific ARARs for landfills would apply. Action-specific ARARs would be addressed. Proposed Chapter NR 720 clean-up standards would be met.	Would be capable of maintaining protection of human health and groundwater because contaminants are removed and permanently treated.	24DNT would be treated on-site. Residuals generated from treatment would be appropriately disposed of off-site.	Fugitive dust from construction site could result in risk to the community. Exposing contaminated soils increases risk to site workers.	Excavation contractor must use employees who have current OSHA Site Worker Protection training. Soil washing vendors have limited availability. Treatability testing required before implementation.	Total Present Worth: $4,993,000 Capital Costs: $4,885,000 Annual O&M Costs: $108,000

(continued)

TABLE ES-2
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARS	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative DBG-SB7: On-Site Incineration	Protective of human health because soils will be excavated and treated to below RGs.	Location-specific ARARs for landfills would apply. Action-specific ARARs would be addressed. Proposed Chapter NR 720 clean-up standards would be met.	Would be capable of maintaining protection of human health and groundwater because contaminants are removed and permanently treated.	24DNT would be treated on-base. Residuals generated from treatment would be appropriately disposed of off-site.	Fugitive dust from construction site could result in risk to the community. Exposing contaminated soils increases risk to site workers. Transportation of contaminated soils across the base for treatment increases risk.	Excavation contractor must use employees who have current OSHA Site Worker Protection training. Will only be implemented if on-site incineration is implemented at the Propellant Burning Ground.	Total Present Worth: $6,553,000 Capital Costs: $6,445,000 Annual O&M Costs: $108,000
Alternative DBG-SB8: Composting	Protective of human health because soils will be excavated and treated to below RGs.	Location-specific ARARs for landfills would apply. Action-specific ARARs would be addressed. Proposed Chapter NR 720 soil clean-up standards would be met.	Would be capable of maintaining protection of human health and groundwater because contaminants are removed and permanently treated.	24DNT would be treated on-site. No residuals resulting from treatment.	Fugitive dust from construction site could result in risk to the community. Exposing contaminated soils increases risk to site workers.	Excavation contractor must use employees who have current OSHA Site Worker Protection training.	Total Present Worth: $4,461,000 Capital Costs: $3,330,000 Annual O&M Costs: $1,131,000

(continued)

TABLE ES-2
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARS	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative DBG-GW1: Minimal Action	Possibly protective of human health because institutional controls will prohibit the use of this aquifer as a drinking water source and groundwater monitoring would ensure no contamination has migrated to the regional aquifer. Contaminant concentrations would not be reduced to safe levels until the source area is identified and remediated.	Would not meet chemical-specific ARARs, unless source areas are located and remediated. Location- and action-specific ARARs do not apply.	This alternative would not meet RGs, however residual risk to human health is low.	Contamination is not treated or destroyed; no reduction of toxicity, mobility or volume of contamination.	No adverse impacts to community or environment during implementation.	No implementability concerns.	Total Present Worth: $845,000 Capital Costs: $10,000 Annual O&M Costs: $835,000
Alternative DBG-GW2: IRM and Carbon Adsorption	Possibly protective of human health because contaminant migration of contaminated groundwater to the regional aquifer would be reduced. Contaminant concentrations would not be reduced to safe levels until the source area is identified and remediated.	Would not meet chemical-specific ARARs unless source area is identified and remediated. Location-specific ARARs do not apply. Action-specific ARARs would be attained.	This alternative would not meet RGs, however residual risk to human health is low.	Contaminants are destroyed; reduction of toxicity. Extraction system reduces mobility. Unless source area remediated, no reduction of volume.	Potential for adverse impacts to community or environment when transporting contaminated groundwater.	Significant technical difficulties associated with extraction of groundwater from the elevated aquifer.	Total Present Worth: $2,008,000 Capital Costs: $1,239,000 Annual O&M Costs: $769,000

(continued)

TABLE ES-2
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative DBG-GW4: IRM and Air Stripping-Carbon Adsorption	Possibly protective of human health because contaminant migration of contaminated groundwater to the regional aquifer would be reduced. Contaminant concentrations would not be reduced to safe levels until the source area is identified and remediated.	Would not meet chemical-specific ARARs unless source area is identified and remediated. Location-specific ARARs do not apply. Action-specific ARARs would be attained.	This alternative would not meet RGs, however residual risk to human health is low.	Contaminants are destroyed; reduction of toxicity. Extraction system reduces mobility. Unless source area remediated, no reduction of volume.	Potential for adverse impacts to community or environment when transporting contaminated groundwater.	Significant technical difficulties associated with extraction of groundwater from the elevated aquifer.	Total Present Worth: $2,008,000 Capital Costs: $1,239,000 Annual O&M Costs: $769,000
Alternative DBG-GW5: IRM and Resin Adsorption	Possibly protective of human health because contaminant migration of contaminated groundwater to the regional aquifer would be reduced. Contaminant concentrations would not be reduced to safe levels until the source area is identified and remediated.	Would not meet chemical-specific ARARs unless source area is identified and remediated. Location-specific ARARs do not apply. Action-specific ARARs would be attained.	This alternative would not meet RGs, however residual risk to human health is low.	Contaminants are destroyed; reduction of toxicity. Extraction system reduces mobility. Unless source area remediated, no reduction of volume.	Potential for adverse impacts to community or environment when transporting contaminated groundwater.	Significant technical difficulties associated with extraction of groundwater from the elevated aquifer.	Total Present Worth: $2,008,000 Capital Costs: $1,239,000 Annual O&M Costs: $769,000

(continued)

TABLE ES-2
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative DBG-GW6: IRM and UV/Reduction, Carbon Adsorption	Possibly protective of human health because contaminant migration of contaminated groundwater to the regional aquifer would be reduced. Contaminant concentrations would not be reduced to safe levels until the source area is identified and remediated.	Would not meet chemical-specific ARARs unless source area is identified and remediated. Location-specific ARARs do not apply. Action-specific ARARs would be attained.	This alternative would not meet RGs, however residual risk to human health is low.	Contaminants are destroyed; reduction of toxicity. Extraction system reduces mobility. Unless source area remediated, no reduction of volume.	Potential for adverse impacts to community or environment when transporting contaminated groundwater.	Significant technical difficulties associated with extraction of groundwater from the elevated aquifer.	Total Present Worth: $2,008,000 Capital Costs: $1,239,000 Annual O&M Costs: $769,000

(continued)

TABLE ES-2
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION OF MOBILITY, TOXICITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
NG/RPA-SS1: Minimal Action	Reduces risks to humans and some ecological receptors (e.g., deer) by restricting access to the NG/RPA area. Does not meet groundwater quality requirements of NR 720.	Would not meet chemical-specific ARARs. Location- and action-specific ARARs do not apply.	Not applicable because remedial action objectives are not achieved.	Contamination is not treated or destroyed; no reduction of toxicity, mobility or volume of contaminants.	Minimal impact to community or workers during implementation.	Very easily implemented.	Total Present Worth: $2,425,000 Capital Cost: $719,000 Annual O&M: $111,000
NG/RPA-SS2: Soil Cover	Meets remedial action objectives by reducing exposure risks to human and ecological receptors by reducing exposure to surface soil/sediment. Does not meet groundwater quality requirements of NR 720.	Would not meet chemical-specific ARARs. Location-specific ARARs for wetlands apply. Action-specific ARARs would be attained.	If properly maintained, will effectively prevent exposure of human and ecological receptors. Does not provide long-term protection of groundwater.	Contamination is not treated or destroyed; no reduction of toxicity, mobility or volume of contaminants.	Using dust depression techniques and general health and safety practices would result in minimal risks to workers. Minimal impact on community during implementation. Impact on waterfowl at the NG Pond during implementation.	Cover system easily installed.	Total Present Worth: $2,995,000 Capital Cost: $1,243,000 Annual O&M: $114,000
NG/RPA-SS3: Excavation/ Solidification/On-site Disposal	Eliminates exposure risks to human and ecological receptors at the NG/RPA by removing contaminated surface soil/sediment. Contaminated soil/ sediment would, though, remain at BAAP. Groundwater quality requirements of NR 720 are met.	Would meet chemical-specific ARARs. Location-specific ARARs would apply. Action-specific ARARs would be attained.	Would be capable of maintaining protection at the NG/RPA because the contaminated soil would have been removed. Effective at the on-site disposal location as long as the location remains secure.	No reduction in toxicity. Stabilization/solidification would greatly reduce mobility. Volume of soil would increase by 20-30% (though not increasing actional amount of contamination).	Same as for NG/RPA-SS2 except excavation of contamination would increase risks to workers.	Excavation easily performed. Stabilization/solidification technology easily implemented.	Total Present Worth: $12,910,000 Capital Cost: $12,910,000 Annual O&M: $0

(continued)

TABLE ES-2
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION OF MOBILITY, TOXICITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
NG/RPA-SS4: Excavation/Off-site Disposal	Eliminates exposure risks to human and ecological receptors at the NG/RPA by removing contaminated surface soil/sediment. Groundwater quality requirements of NR 720 are met.	Would meet chemical-specific ARARs. Location-specific ARARs would apply. Action-specific ARARs would be attained.	Would be capable of maintaining protection at the NG/RPA because the contaminated soil would have been removed. Effective at the off-site disposal facility as long as the facility is maintained.	No reduction in toxicity or volume. Mobility would be greatly reduced as contaminated surface soil/sediment would be placed in a permitted off-site disposal facility.	Same as for NG/RPA-SS2 except excavation of contamination would increase risks to workers.	Excavation easily performed. Transportation and off-site disposal easily implemented.	Total Present Worth: $34,743,000 Capital Cost: $34,743,000 Annual O&M: $0
NG/RPA-SS5: In-Situ Solidification/ Soil Cover	Achieves remedial action objectives for human and ecological receptors. Groundwater requirements of NR 720 are met.	Would meet chemical-specific ARARs. Location-specific ARARs would apply, action-specific ARARs would be met.	Would be capable of maintaining protection of NG/RPA as long as treated soil/sediment and the soil cover remain intact.	No reduction in toxicity. Stabilization/solidification would greatly reduce mobility. Volume of soil would increase by 20% to 30% (though not increasing actual amount of contamination.	Same as for NG/RPA-SS2.	Stabilization/solidification technology easily implemented. Cover system easily installed.	Total Present Worth: $9,398,000 Capital Cost: $7,184,000 Annual O&M: $144,000

Notes:

RG = Remediation Goal
ARARs = Applicable or Relevant and Appropriate Requirements

(continued)

TABLE ES-2
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE WATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARS	EFFECTIVENESS: LONG-TERM	REDUCTION OF MOBILITY, TOXICITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
NG/RPA-SW1: Minimal Action	Reduces risks to some ecological receptors (e.g., deer) by restricting access to the ponds.	Would not meet chemical-specific ARARs. Location- and action-specific ARARs do not apply.	Not applicable because remedial action objectives are not achieved.	Contamination is not treated or destroyed; no reduction of toxicity, mobility or volume of contaminants.	Minimal impact to community or workers during implementation.	Easily implementable.	Total Present Worth: $349,000 Capital Cost: $138,000 Annual O&M: $13,000
NG/RPA-SW2: Precipitation/ Microfiltration	Meets remedial action objectives by reducing risks to ecological receptors by reducing metals concentrations in the surface water to RGs (except for HG whose RG may not be met with currently available technology).	Chemical-specific ARARs (i.e., RGs) would be met (except for possibly HG). Wetland protection ARARs would be met. Action-specific ARARs would be attained.	Would be capable of maintaining protection as long as future runoff would not carry contamination into the NG Pond.	Toxicity and volume would not be reduced. Metals would be concentrated into a residual sludge. Mobility would be reduced by disposal of residual sludge at a licensed off-site disposal facility.	Minimal impact to the community during implementation. Minimal risk to workers if proper health and safety procedures are followed. Water quality may be adversely affected by chemicals used during precipitation.	No implementability concerns. Processes can be adapted to treat a wide variety of waste streams.	Total Present Worth: $843,000 Capital Cost: $843,000 Annual O&M: $0
NG/RPA-SW3: Ion Exchange	Would reduce risks to human and ecological receptors, but may not reduce metals concentrations to RGs.	Chemical-specific ARARs (i.e., RGs) would not be met. Wetland protection ARARs would be met. Action-specific ARARs would be attained.	Not applicable because remedial action objectives may not be achieved.	Toxicity or volume would not be reduced. Metals would concentrated into filters and metal sheets. Mobility of metals in spent filters would be reduced by disposal of spent filters at a licensed off-site disposal facility. Metal sheets would not require special disposal.	Minimal impact to the community during implementation. Minimal risk to workers if proper health and safety procedures are followed.	Significant implementability concerns. Process is subject to breakthrough and leakage of metals.	Total Present Worth: $843,000 Capital Cost: $843,000 Annual O&M: $0

Notes:

RG = Remediation Goal
ARARs = Applicable or Relevant and Appropriate Requirements

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(continued)

Table ES-2
Comparative Summary of Remedial Alternatives
Final Creek, Settling Ponds and Spoils Disposal Area Soil

Feasibility Study
Badger Army Ammunition Plant

Alternative	Overall Protection	Compliance with ARARs	Effectiveness: Long-Term	Reduction in Toxicity, Mobility, and Volume	Effectiveness: Short-Term	Implementability	Cost
Alternative SSP-SS1: Minimal Action	Somewhat protective of human health. Does not reduce risk to environmental receptors.	Does not meet proposed Chapter NR 720 requirements. Location-specific ARARs do not apply. Action-specific ARARs would be met.	Remedial action objectives are not achieved.	Contamination is not treated or destroyed; no reduction in toxicity, mobility, or volume.	No adverse community or environmental impacts.	No implementability concerns.	Total Present Worth: $2,859,000 Capital Costs: $10,000 Annual O&M: $2,849,000
Alternative SSP-SS3: Capping	Protective of human and environmental receptors.	Meets groundwater protection requirements of proposed Chapter NR 720. Location-specific ARARs for wetlands may apply. Action-specific ARARs would be addressed.	Untreated soil would remain on site, although remedial action objectives would be met.	Contamination is not treated or destroyed; no reduction in toxicity, or volume. Potential contaminant mobility is significantly reduced.	No adverse impacts to the community. The cap may disrupt the habitat of burrowing animals during implementation.	Easily implemented. A soil borrow study must be done on each source.	Total Present Worth: $33,797,000 Capital Costs: $30,784,000 Annual O&M: $3,013,000
Alternative SSP-SS7: Modified In Situ Stabilization/ Solidification and Soil Cover	Achieves remedial action objectives for protection of human health and the environment.	Meets groundwater protection requirements of proposed Chapter NR 720. Location-specific ARARs for wetlands may apply. Action-specific ARARs would be addressed.	Provided the soil cover remains intact, there would be negligible residual risk to human and ecological receptors.	There is not reduction in toxicity or volume of contaminants. Treatment residuals are resistant to leaching and erosion.	No adverse impacts to the community. Rototilling and placing the soil cover may disrupt the habitat of burrowing animals during implementation.	Technology and equipment is available from a limited number of vendors.	Total Present Worth: $67,492,000 Capital Costs: $64,479,000 Annual O&M: $3,013,000

(continued)

TABLE ES-2
COMPARATIVE SUMMARY OF GROUNDWATER ALTERNATIVES
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative SOPA-GW1: Minimal Action	Achieves remedial action objectives.	WPALs would be achieved in approximately 66 years (estimated using USEPA batch flushing model) after implementation of the BAAP control wells. Location-specific and action-specific ARARs do not apply.	Interception of the contaminant plume at the southern base boundary would result in eventual decreases in contaminant concentrations and residual risk downgradient (i.e., Southern Off-Post Area) of BAAP.	Contamination is not treated or destroyed; no reduction of toxicity, mobility, or volume of contaminants.	No adverse community or environmental impacts during implementation	No implementability concerns.	Total Present Worth: <u>$2,889,000</u> Capital Cost: $50,000 Annual O&M: $184,000
Alternative SOPA-GW2: Air Stripping	Achieves remedial action objectives.	WPALs would be achieved in approximately 61, 34, or 17 years for Scenarios 1, 2, and 3, respectively (estimated using USEPA batch flushing model) after implementation of BAAP control wells. Capable of achieving WPDES and air permit limits.	This alternative would be implemented to comply with WPALs and secondary drinking water standards. The standards were developed to minimize risk. Also, the contaminant plume would be intercepted at the base boundary; therefore, the magnitude of the residual risk would be minimal.	Removal efficiency greater than 99%. Approximately 24,000 lbs, 48,000 lbs, and 96,000 lbs of spent carbon would be generated every 10 years for groundwater extraction Scenarios 1, 2, and 3, respectively.	No adverse impacts to community. Potentially adverse impacts to environment during construction of extraction system.	No treatment-related implementability concerns. Technologies have been proven full-scale. No problems expected permitting discharge or air emissions. It is assumed that property easements can be easily obtained.	<u>GES 1</u> Total Present Worth: <u>$20,215,000</u> Capital Cost: $6,378,000 Annual O&M: $729,000 <u>GES 2</u> Total Present Worth: <u>$29,583,000</u> Capital Cost: $11,155,000 Annual O&M: $1,138,000 <u>GES 3</u> Total Present Worth: <u>$42,841,000</u> Capital Cost: $21,364,000 Annual O&M: $1,905,000

Table ES-2
Comparative Summary of Groundwater Alternatives
Southern Off-Post Area Groundwater

Feasibility Study
Badger Army Ammunition Plant

Alternative	Overall Protection	Compliance with ARARs	Effectiveness: Long-Term	Reduction in Toxicity, Mobility, and Volume	Effectiveness: Short-Term	Implementability	Cost
Alternative SOPA-GW3: Carbon Adsorption	Achieves remedial action objectives.	WPALs would be achieved in approximately 61, 34, or 17 years for Scenarios 1, 2, and 3, respectively (estimated using USEPA batch flushing model) after implementation of BAAP control wells. Capable of achieving WPDES permit limits.	This alternative would be implemented to comply with WPALs and secondary drinking water standards. The standards were developed to minimize risk. Also, the contaminant plume would be intercepted at the base boundary; therefore, the magnitude of the residual risk would be minimal.	Removal efficiency greater than 99%. Approximately 120,000 lbs, 240,000 lbs, and 480,000 lbs of spent carbon would be generated annually for groundwater extraction Scenarios 1, 2, and 3, respectively. Off-site destruction of contaminants.	No adverse impacts to community. Potentially adverse impacts to environment during construction of extraction system.	No treatment-related implementability concerns. Technologies have been proven full-scale. No problems expected permitting discharge. It is assumed that property easements can be easily obtained.	GES 1 Total Present Worth: $22,079,000 Capital Cost: $6,477,000 Annual O&M: $822,000 GES 2 Total Present Worth: $33,119,000 Capital Cost: $11,501,000 Annual O&M: $1,335,000 GES 3 Total Present Worth: $48,167,000 Capital Cost: $22,192,000 Annual O&M: $2,304,000

Notes:

ARARs = Applicable or Relevant and Appropriate Requirements
GES1 = Groundwater extraction Scenario 1
GES2 = Groundwater extraction Scenario 2
GES3 = Groundwater extraction Scenario 3
WPALs = Wisconsin Preventative Action Limits
WPDES = Wisconsin Pollution Discharge Elimination System

TABLE ES-3
RECOMMENDED ALTERNATIVES SUMMARY

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

WASTE MANAGEMENT AREA	RECOMMENDED ALTERNATIVE
Propellant Burning Ground Groundwater	IRM and Air Stripping-Carbon Adsorption
Propellant Burning Ground Waste Pits	In Situ Vapor Extraction, Soil Washing, and Composting
Propellant Burning Ground Subsurface Soil	Capping
Propellant Burning Ground Surface Soil	Modified In Situ Solidification/Stabilization
Deterrent Burning Ground Groundwater	Minimal Action
Deterrent Burning Ground Subsurface Soil	Soil Washing
Nitroglycerine Pond/Rocket Paste Area Surface Soil	In Situ Solidification/Stabilization
Nitroglycerine Pond/Rocket Paste Area Surface Water	Precipitation/Microfiltration
Settling Ponds/Spoils Disposal Area Soil	In Situ Solidification/Stabilization
Off-Post Area South of BAAP	Minimal Action

TABLE 1-1
SUMMARY OF ELEVEN WASTE MANAGEMENT AREAS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

WASTE MANAGEMENT AREA	REQUIRES REMEDIAL ACTION	REMEDIAL ACTION NOT RECOMMENDED
Propellant Burning Ground	X	
Deterrent Burning Ground	X	
Rocket Paste Area	X	
Nitroglycerine Pond	X	
Settling Ponds and Spoils Disposal Area	X	
Existing Landfill		X
Ballistics Pond		X
Oleum Plant and Pond		X
New Acid Area		X
Old Acid Area		X
Old Fuel Oil Tank		X

TABLE 1-2
DEVELOPMENT OF CLEAN-UP LEVELS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
Concentration Soil	CS	See below	mg/kg	Calculated
Ingestion Rate	IR	100	mg/day	NR 720
Inhalation Rate	IhR	24	m^3/day	NR 720
Target Risk Level	TR	1E−06		NR 720
Target Hazard Index	THI	1		NR 720
Body Weight	BW	70	kg	NR 720
Conversion Factor − oral	CF_o	0.000001	kg/mg	
Exposure Duration	ED	25	years	NR 720
Exposure Frequency	EF	245	days/year	NR 720
Averaging Time				
Cancer	AT	70	years	NR 720
Noncancer	AT	25	years	NR 720
PM_{10} Concentration	PM10	1.4	ug/m^3	NR 720
Conversion Factor − inhal.	CF_i	1E−09	kg/ug	

Source of Cancer Slope Factors and Reference Doses is IRIS, 1994 and HEAST, 1993 (including July and November updates).

EQUATIONS

CS−Carcinogenic =

$$\frac{TR \times BW \times AT \times 365 \text{ days/year}}{EF \times ED \times ((SF_o \times CF_o \times IR) + (SF_i \times IhR \times PM10 \times CF_i))}$$

CS−Noncarcinogenic =

$$\frac{THI \times BW \times AT \times 365 \text{ days/year}}{ED \times EF \times ((1/RfD_o \times CF \times IR) + (1/RfD_i \times IhR \times PM10 \times CF_i))}$$

Note:

For noncarcinogenic effects: AT = EF x 365 days/year

SF_i = Cancer Slope Factor − Inhalation

SF_o = Cancer Slope Factor − Oral

RFD_i = Reference Dose − Inhalation

RfD_o = Reference Dose − Oral

TABLE 1-2
DEVELOPMENT OF CLEAN-UP LEVELS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

PRELIMINARY REMEDIATION GOAL

COMPOUND	SF_o $(mg/kg-day)^{-1}$	RfD_o (mg/kg-day)	SF_i $(mg/kg-day)^{-1}$	RfD_i (mg/kg-day)	CS Carcinogenic (mg/kg)	CS Noncarcinogenic (mg/kg)
acenaphthene	ND	6.00E-02	ND	ND		62580
acenaphthylene	ND	4.00E-02	ND	ND		41720
anthracene	ND	3.00E-01	ND	ND		312900
arsenic	1.75E+00	3.00E-04	1.51E+01	ND	1.62	312.9
barium	ND	7.00E-02	ND	1.00E-04		59100
benzene	2.90E-02	ND	2.90E-02	ND	100.35	
benzo(g,h,i)perylene	ND	4.00E-02	ND	ND		41720
beryllium	4.30E+00	5.00E-03	8.40E+00	ND	0.67	5215
carbon tetrachloride	1.30E-01	7.00E-04	5.30E-02	ND	22.43	730.1
carcinogenic PAHs	7.3E+00	ND	ND	ND	0.40	
chloroform	6.10E-03	1.00E-02	8.10E-02	ND	458.24	10430
chromium (hexavalent)	ND	5.00E-03	4.10E+01	ND	211.95	5215
chromium (trivalent)	ND	1.00E+00	ND	ND		1043000
copper	ND	3.70E-02	ND	ND		38591
diethylphthalate	ND	8.00E-01	ND	ND		834400
ethane, 1,1,1-trichloro	ND	9.00E-02	ND	ND		93870
ethane, 1,1,2-trichloro	5.70E-02	4.00E-03	5.70E-02	ND	51.06	4172
fluoranthene	ND	4.00E-02	ND	ND		41720
fluorene	ND	4.00E-02	ND	ND		41720
manganese (food)	ND	1.40E-01	ND	1.00E-04		99293
manganese (water)	ND	5.00E-03	ND	1.00E-04		5128
mercury	ND	3.00E-04	ND	8.60E-05		312
methylene chloride	7.50E-03	6.00E-02	1.60E-03	9.00E-01	389.05	62570
naphthalene	ND	4.00E-02	ND	ND		41720
nickel	ND	2.00E-02	ND	ND		20860
nitrite	ND	1.00E-01	ND	ND		104300
nitrosodimethylamine, N-	5.10E+01	ND	5.10E+01	ND	0.06	
n-nitrosodiphenylamine	4.90E-03	ND	ND	ND	595.92	
phenanthrene	ND	4.00E-02	ND	ND		41720
phthalate, bis(2-ethylhexyl)	1.40E-02	2.00E-02	ND	ND	208.57	20860
phthalate, di-n-butyl	ND	1.00E-01	ND	ND		104300
phthalate, di-n-octyl-	ND	2.00E-02	ND	ND		20860
pyrene	ND	3.00E-02	ND	ND		31290
selenium	ND	5.00E-03	ND	ND		5215
tin	ND	6.00E-01	ND	ND		625800
toluene	ND	2.00E-01	ND	1.00E-01		208432
toluene, 2,4-dinitro	6.80E-01	2.00E-03	ND	ND	4.29	2086
toluene, 2,6-dinitro	6.80E-01	1.00E-03	ND	ND	4.29	1043
trichloroethene	1.10E-02	ND	6.00E-03	ND	264.97	
vanadium	ND	7.00E-03	ND	ND		7301
xylene, mixture	ND	2.00E+00	ND	ND		2086000
zinc	ND	3.00E-01	ND	ND		312900

TABLE 1-3
CRITERIA FOR EVALUATION OF ALTERNATIVES

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

CRITERIA	DESCRIPTION
Overall protection of human health and environment	Describes how each alternative satisfies the remedial action objectives; protects human health and environment.
Compliance with ARARs	Describes how the alternative complies with ARARs, or if a waiver is required and how it is justified.
Long-term effectiveness and permanence	Evaluates the effectiveness in protecting human health and environment after response objectives have been met.
Reduction of toxicity, mobility, or volume through treatment	Evaluates the anticipated performance of the specific treatment technologies.
Short-term effectiveness	Examines the effectiveness of alternatives in protecting human health and environment during the construction and implementation period until response objectives are met.
Implementability	Assesses the technical and administrative feasibility of alternatives and the availability of required resources.
Cost	Evaluates the capital, operation and maintenance costs of each alternative.
State acceptance*	Evaluates the technical and administrative issues and concerns the state may have.
Community Acceptance*	Evaluates the issues and concerns the public may have.

Notes:

* This criterion will be addressed once comments on the Final Feasibility Study have been received.

ARARs = Applicable or Relevant and Appropriate Requirements

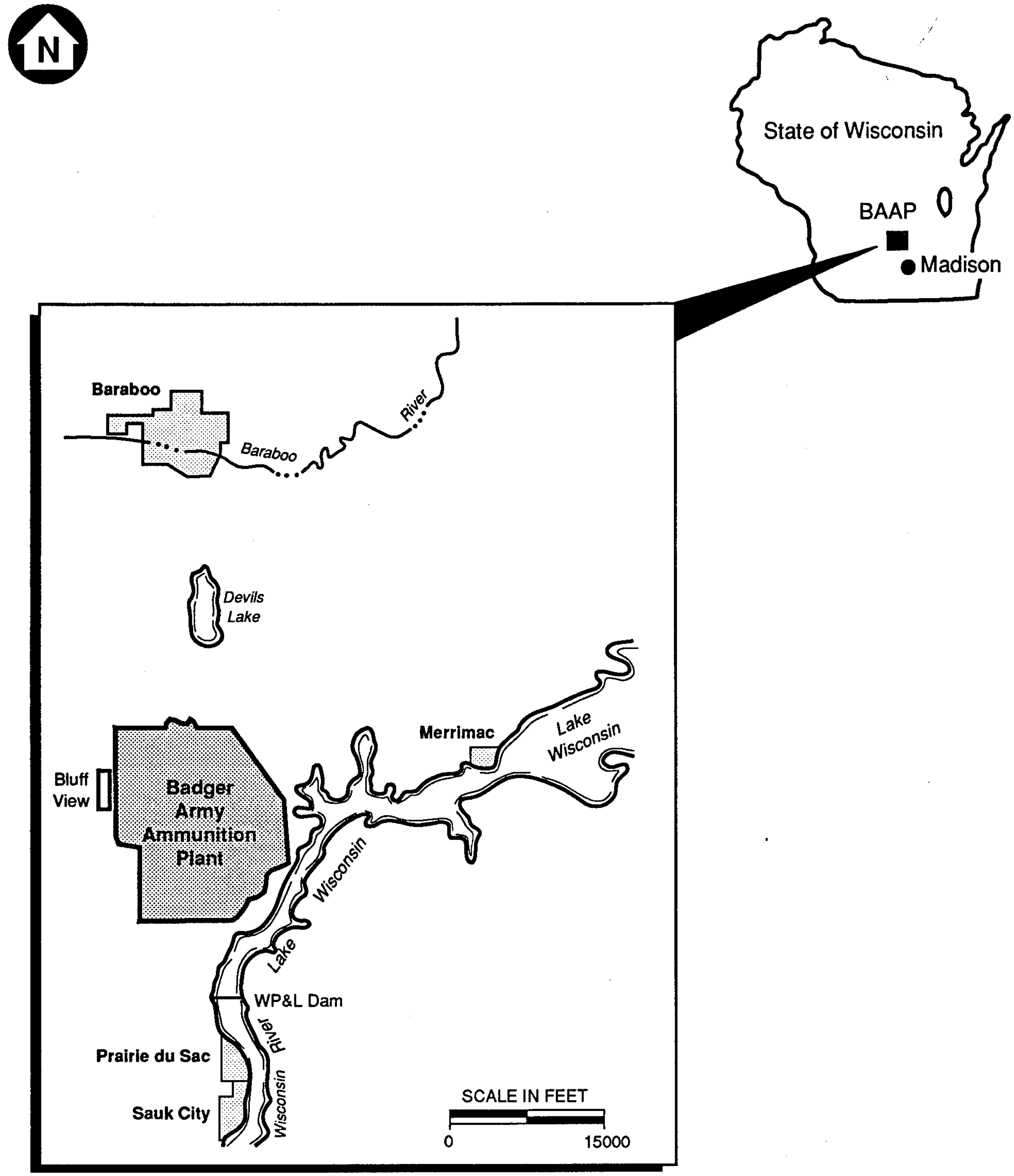

FIGURE 1-1
SITE LOCATION MAP
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Source: Modified from Tsai, et.al., 1988.

ABB Environmental Services, Inc.

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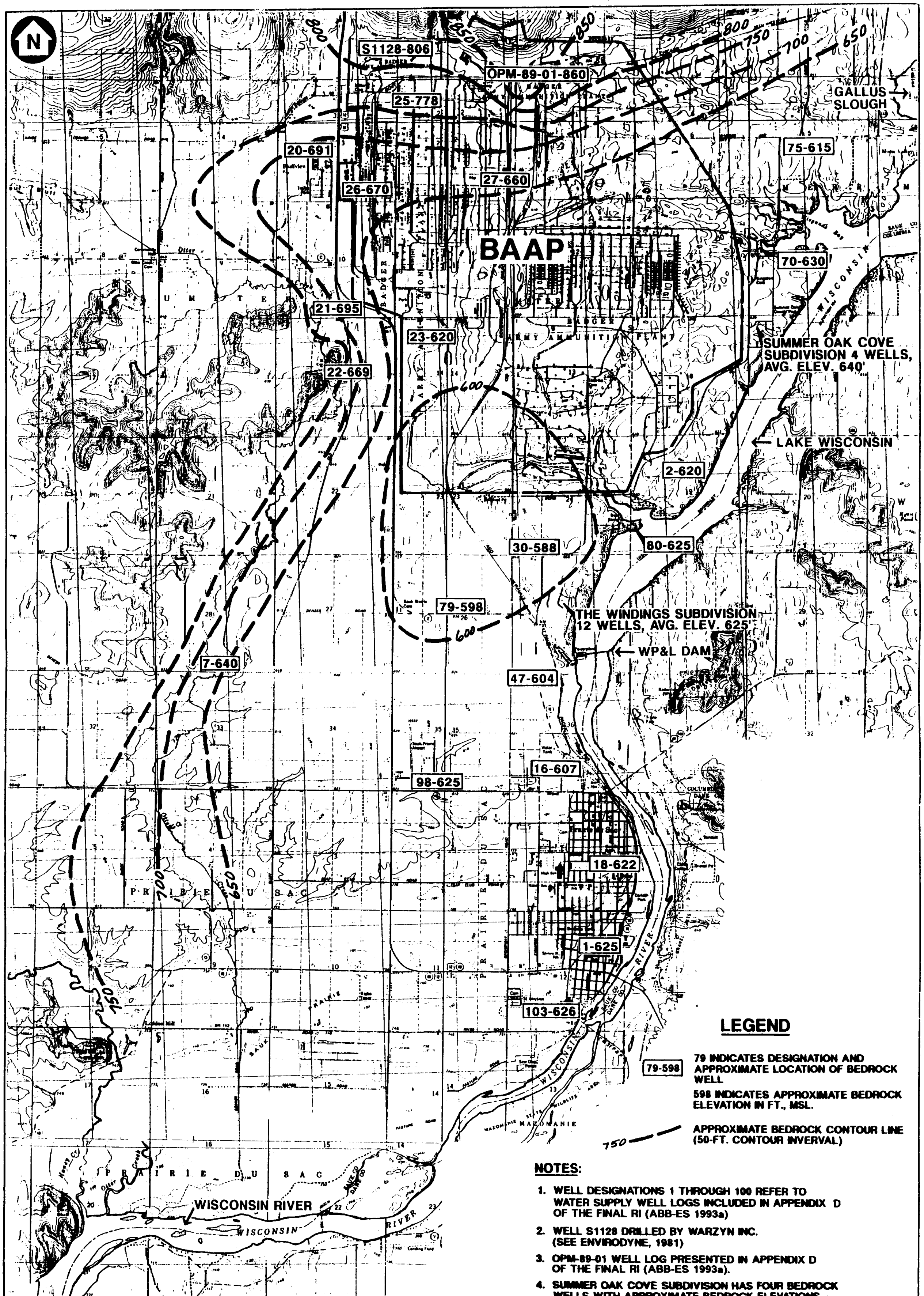

LEGEND

79-598 — 79 INDICATES DESIGNATION AND APPROXIMATE LOCATION OF BEDROCK WELL
598 INDICATES APPROXIMATE BEDROCK ELEVATION IN FT., MSL.

750 — APPROXIMATE BEDROCK CONTOUR LINE (50-FT. CONTOUR INVERVAL)

NOTES:

1. WELL DESIGNATIONS 1 THROUGH 100 REFER TO WATER SUPPLY WELL LOGS INCLUDED IN APPENDIX D OF THE FINAL RI (ABB-ES 1993a)
2. WELL S1128 DRILLED BY WARZYN INC. (SEE ENVIRODYNE, 1981)
3. OPM-89-01 WELL LOG PRESENTED IN APPENDIX D OF THE FINAL RI (ABB-ES 1993a).
4. SUMMER OAK COVE SUBDIVISION HAS FOUR BEDROCK WELLS WITH APPROXIMATE BEDROCK ELEVATIONS RANGING FROM 630 TO 650 FT., MSL.
5. THE WINDINGS SUBDIVISION HAS 12 BEDROCK WELLS WITH APPROXIMATE BEDROCK ELEVATIONS RANGING FROM 557 TO 665 FT., MSL.

SOURCE: USGS TOPOGRAPHIC QUADRANGLES 7.5-MINUTE SERIES; SAUK PRAIRIE, SAUK CITY, NORTH FREEDOM AND BARABOO.

SCALE IN FEET
0 4000 8000

FIGURE 1-3
BEDROCK SURFACE CONTOUR PLAN
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

6853-12

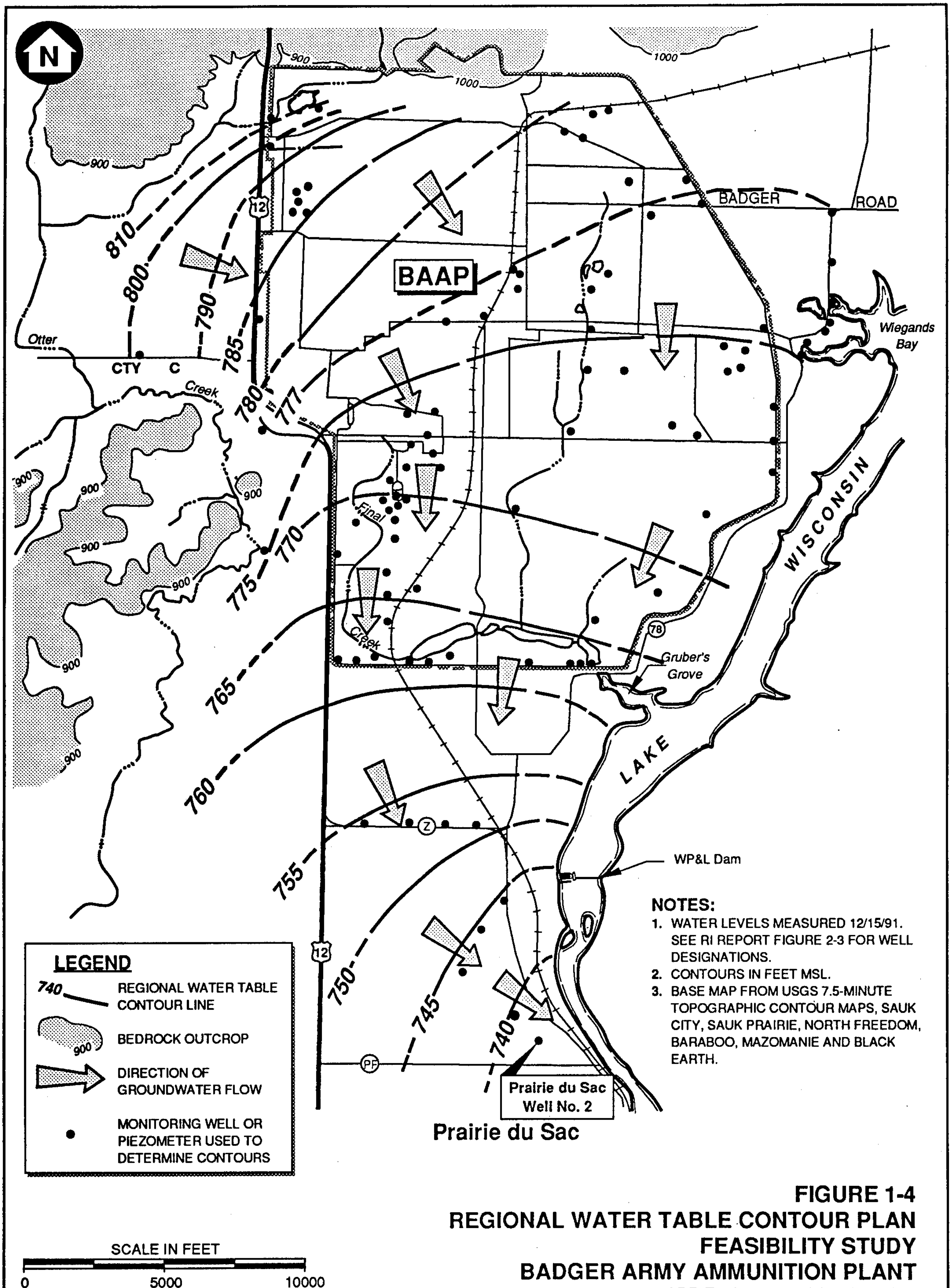

FIGURE 1-4
REGIONAL WATER TABLE CONTOUR PLAN
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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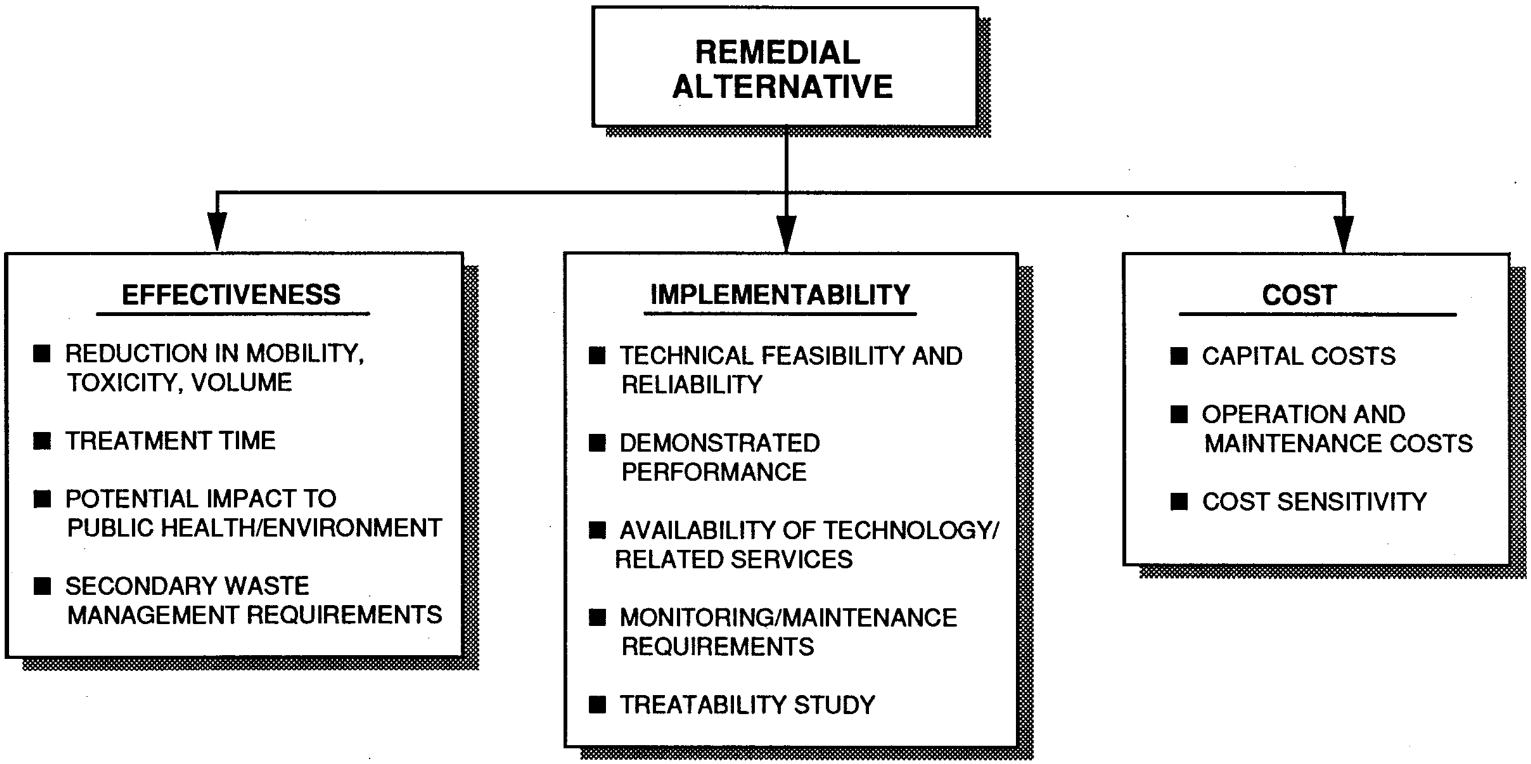

FIGURE 1-5
REMEDIAL ALTERNATIVE EVALUATION CRITERIA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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TABLE 2-1
CHECKLIST OF WASTE MANAGEMENT AREA ENVIRONMENTAL SETTING AND FEATURES

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

WASTE MANAGEMENT AREA	WETLANDS	SURFACE WATER	SURFACE IMPOUNDMENT	LANDFILL	ABOVEGROUND STORAGE TANK
Propellant Burning Ground				X	X (propane)
Deterrent Burning Ground				X	
Existing Landfill				X	
Settling Ponds and Spoils Disposal Area	X	X	X	X	
Ballistics Pond	X	X			
Oleum Plant and Pond	X	X			
Nitroglycerine Pond	X	X			
Rocket Paste Area	X	X			
Old Acid Area					X (acids)
New Acid Area			X		X (acids)
Old Fuel Oil Tank					X (fuel)

Note:

The landfill at the Propellant Burning Ground is known as Landfill 1, and is considered a separate SWMU within the PBG Waste Management Area.

continued

TABLE 2-2
POTENTIAL LOCATION-SPECIFIC
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

SITE	POTENTIAL ARARs/CITATION
Settling Ponds and Spoils Disposal Area	WETLANDS CAA, PSD Requirements; (40 CFR, Part 52.21) Clean Water Act (CWA), Dredge or Fill Requirements; (Section 404), 40 CFR 230 U.S. Army Corps of Engineers Permit Program Regulations; (33 CFR Parts 320-330) Fish and Wildlife Coordination Act; (40 CFR 302(g)) National Environmental Policy Act (NEPA) - Protection of Wetlands Exec. Order No. 11990; (40 CFR Part 6) WDNR, Water Quality Standards for Wetlands (WAC, Chapter NR 103) WDNR, City and Village Shoreland-Wetland Protection Program (WAC, Chapter NR 117) WDNR, Hazardous Waste Storage, Treatment, and Disposal Facility Standards (WAC, NR 630) SURFACE WATER WDNR, Water Quality Standards for Wisconsin Waters (WAC, Chapter NR 102) WDNR, Water Quality Standards for Wisconsin Waters; Uses and Designated Standards (WAC, Chapter NR 104) WDNR, Shoreline Management Program (WAC, Chapter 115) WDNR, Wisconsin Statutes Annotated, Chapter 30, Dredge and Fill Requirements City of Baraboo Floodplain Zoning Code (Subchapter II) LANDFILL RCRA, Subpart N, Landfills; (40 CFR Section 264.300)

continued

TABLE 2-2
POTENTIAL LOCATION-SPECIFIC
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

SITE	POTENTIAL ARARs/CITATION
Oleum Plant and Pond	<u>WETLANDS</u> CWA, Dredge or Fill Requirements; (Section 404), 40 CFR 230 U.S. Army Corps of Engineers Permit Program Regulations; (33 CFR Parts 320-330) Fish and Wildlife Coordination Act; (40 CFR 302(g)) NEPA - Protection of Wetlands Executive Order Number 11990; (40 CFR Part 6) WDNR, Water Quality Standards for Wetlands (WAC, Chapter NR 103) WDNR, City and Village Shoreland-Wetland Protection Program (WAC, Chapter NR 117) WDNR, Hazardous Waste Storage, Treatment, and Disposal Facility Standards (WAC, NR 630) <u>SURFACE WATER</u> WDNR, Water Quality Standards for Wisconsin Waters (WAC, Chapter NR 102) WDNR, Water Quality Standards for Wisconsin Waters; Uses and Designated Standards (WAC, Chapter NR 104) WDNR, Shoreline Management Program (WAC, Chapter 115) WDNR, Wisconsin Statutes Annotated, Chapter 30, Dredge and Fill Requirements City of Baraboo Floodplain Zoning Code (Subchapter II) <u>AIR</u> CAA, PSD Requirements; (40 CFR, Part 52.21)

continued

TABLE 2-2
POTENTIAL LOCATION-SPECIFIC
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

SITE	POTENTIAL ARARS/CITATION
Rocket Paste Area	WETLANDS CWA, Dredge or Fill Requirements; (Section 404), 40 CFR 230 U.S. Army Corps of Engineers Permit Program Regulations; (33 CFR Parts 320-330) Fish and Wildlife Coordination Act; (40 CFR 302(g)) NEPA - Protection of Wetlands Exec. Order No. 11990; (40 CFR Part 6) WDNR, Water Quality Standards for Wetlands (WAC, Chapter NR 103) WDNR, City and Village Shoreland-Wetland Protection Program (WAC, Chapter NR 117) WDNR, Hazardous Waste Storage, Treatment, and Disposal Facility Standards (WAC, NR 630) SURFACE WATER WDNR, Water Quality Standards for Wisconsin Waters (WAC, Chapter NR 102) WDNR, Water Quality Standards for Wisconsin Waters; Uses and Designated Standards (WAC, Chapter NR 104) WDNR, Shoreline Management Program (WAC, Chapter 115) WDNR, Wisconsin Statutes Annotated, Chapter 30, Dredge and Fill Requirements City of Baraboo Floodplain Zoning Code (Subchapter II) AIR CAA, PSD Requirements; (40 CFR, Part 52.21)
Old Acid Area	AIR CAA, PSD Requirements; (40 CFR, Part 52.21)

continued

TABLE 2-3
POTENTIAL CHEMICAL-SPECIFIC
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

SITE MEDIA	REQUIREMENT/CITATION
Federal Criteria, Advisories, and Guidance	Clean Water Act (CWA), Ambient Water Quality Criteria (AWQC); (40 CFR Part 131 Quality Criteria for Water, 1986)
	SDWA, National Secondary Drinking Water Standards (SMCLs); (40 CFR Part 143)
	EPA Reference Doses (RfDs)
	EPA Reference Concentrations (RfCs)
	EPA Human Health Assessment Cancer Slope Factors (CSFs)
	EPA Office of Drinking Water, Health Advisories
	EPA Health Assessment Documents, Acceptable Intake - Chronic (AIC) and Subchronic (AIS)
	EPA, Office of Water Guidance, Water-Related Fate of 129 Priority Pollutants (1979)
SURFACE WATER	
Federal Regulatory Requirements	CWA, National Pollutant Discharge Elimination System (NPDES); (40 CFR Part 122, 125)
	CWA, Ambient Water Quality Criteria (AWQC); (40 CFR Part 131 Quality Criteria for Water, 1986)
State Regulatory Requirements	WDNR, Water Quality Standards for Wisconsin Waters (WAC, Chapter 102.14)
	WDNR, Water Quality Criteria for Toxic Substances (WAC, Chapter 105)
	WDNR, Procedures for Calculating Water-quality-based Effluent Limitations for Toxic and Organoleptic Substances Discharged to Surface Water (WAC, Chapter NR 106)
	WDNR, Pollutant Discharge Elimination System Standards for Uncategorized Point Sources (WAC, Chapter 220.20)

TABLE 2-4
CHEMICAL-SPECIFIC STANDARDS AND GUIDANCE FOR GROUNDWATER AND SURFACE WATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITIONS PLANT

CHEMICAL		SAFE DRINKING WATER ACT (SDWA) (a)		CWA WATER QUALITY CRITERIA (b)				WI PUBLIC HEALTH GROUNDWATER QUALITY STANDARDS (c)	
				FOR PROTECTION OF HUMAN HEALTH		FOR PROTECTION OF AQUATIC LIFE			
CHEMICAL CODE	CHEMICAL NAME	MCL (µg/L)	MCLG (µg/L)	WATER AND FISH CONSUMPTION (µg/L)	FISH CONSUMPTION ONLY (µg/L)	FRESHWATER ACUTE/CHRONIC (µg/L)	MARINE ACUTE/CHRONIC (µg/L)	ENFORCEMENT STANDARDS (µg/L)	PAL (µg/L)
AL	aluminum	50-200 (1)	-	(2)	(2)	(2)	(2)	-	-
ALK	alkalinity	-	-	-	-	- /20,000 ppm	-/-	-	-
AS	arsenic	50 (3)	-	0.0022	0.0175	-/-	-/-	50	5
B2EHP	bis(2-ethylhexyl) phthalate	-	-	15,000	50,000	400/300 (4)	400/360 (4)	3	0.3
BA	barium	2,000	2,000	1,000	-	-/-	-/-	2,000	400
BE	beryllium	4	4	0.0037	0.0641	130/5.3 (4)	-/-	-	-
C6H6	benzene	5	0	0.66	40	5,300/- (5)	5,100/700 (5)	5	0.5
CA	calcium	-	-	-	-	-/-	-/-	-	-
CCL4	carbon tetrachloride	5	0	0.4	6.94	35,200/- (5)	50,000/- (5)	5	0.5
CD	cadmium	5	5	10	-	3.9/1.1 (8)	43/9.3	5	0.5
CHCL3	chloroform	100 (6)	0	0.19	15.7	28,900/1,240(5)	-/-	6	0.6
CL	chloride	250,000 (1)	-	-	-	860,000/230,000	-/-	250,000 (1)	125,000 (1)
CR	chromium (total)	100	100	-	-	-/-	-/-	100	10
CU	copper	TT	1300	1300	-	18/12 (7)	2.9/-	1300	130
24DNT	2,4-dinitrotoluene	-	-	0.11	9.1	330/230 (5)	-/-	0.05	0.005
26DNT	2,6-dinitrotoluene	-	-	-	-	-/-	-/-	0.05	0.005
FE	iron	300 (1)	-	300	-	-/1,000	-/-	300 (1)	150 (1)

continued

TABLE 2-4
CHEMICAL-SPECIFIC STANDARDS AND GUIDANCE FOR GROUNDWATER AND SURFACE WATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITIONS PLANT

CHEMICAL		SAFE DRINKING WATER ACT (SDWA) (a)		CWA WATER QUALITY CRITERIA (b)				WI PUBLIC HEALTH GROUNDWATER QUALITY STANDARDS (c)	
				FOR PROTECTION OF HUMAN HEALTH		FOR PROTECTION OF AQUATIC LIFE			
CHEMICAL CODE	CHEMICAL NAME	MCL (µg/L)	MCLG (µg/L)	WATER AND FISH CONSUMPTION (µg/L)	FISH CONSUMPTION ONLY (µg/L)	FRESHWATER ACUTE/CHRONIC (µg/L)	MARINE ACUTE/CHRONIC (µg/L)	ENFORCEMENT STANDARDS (µg/L)	PAL (µg/L)
111TCE	1,1,1-trichloroethane	200	200	18400	1,030,000	-/-	31,200/- (5)	200	40
112TCE	1,1,2-trichloroethane	5	3	0.6	41.8	-/9,400 (5)	-/-	0.6	0.06
TDS	total dissolved solids	500,000 (1)(11)	-	-	-	-/-	-/-	-	-
TRCLE	trichloroethylene	5	0	2.7	80.7	45,000/21,900 (5)	2,000/- (5)	5	0.5
ZN	Zinc	5000 (1)	-	-	-	120/110 (8)	95/86 (8)	5,000 (1)	2,500 (1)

Sources:

(a) U.S. Environmental Protection Agency (EPA), 1993, "Drinking Water Regulations and Health Advisories." Office of Water, Washington, D.C. May 1993.
(c) Wisconsin Administrative Code, Chapter NR 140.10, Tables 1 and 2.

(b) EPA, 1991. "Water Quality Criteria Summary"; Office of Science and Technology, Health and Ecological Criteria Division, Ecological Risk Assessment Branch, Human Risk Assessment Branch; Washington, D.C. May 1, 1991.

Notes:

(1) Secondary drinking water standards, suggested level
(2) Criteria are pH dependent. Refer to 53FR33178.
(3) MCL for arsenic currently under review.
(4) Proposed value.
(5) Insufficient data to develop criteria. Value presented is the lowest observed effect level.
(6) Standard indicated is proposed value for total trihalomethanes (i.e., chloroform, dibromo-chloro-methane, bromodichloromethane, and bromoform).
(7) No MCL has been set for sodium. However, a reporting level of 20,000 µg/l has been established. Monitoring is required and data is reported to health officials to protect individuals on restricted sodium diet.
(8) Hardness dependent criteria (100 mg/l $CaCO_3$ used).
(9) Standard indicated is for total nitrite/nitrate.
(10) Treatment technique requirement in effect. Action level for lead is 15 µg/L; for copper, 1,300 µg/L.
(11) The Preventative Action Limit for total dissolved solids (TDS) is 200,000 µg/l above an established background concentration (NR 140.20, Table 3); there is no Enforcement Standard for TDS.

Acronyms:

CWA Clean Water Act
EPA United States Environmental Protection Agency
MCL Maximum Contaminant Level
MCLG Maximum Contaminant level Goal
TT Treatment technique
µg/L micrograms per liter, equivalent to parts per billion
mg/L milligrams per liter, equivalent to parts per million
PAL Preventative Action Limit
SDWA Safe Water Drinking Act
TDS Total Dissolved Solids
WDNR Wisconsin Department of Natural Resources

continued

TABLE 2-5
POTENTIAL ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

POTENTIAL ACTION-SPECIFIC ARARs COMMON TO A VARIETY OF REMEDIAL ALTERNATIVES			
OTHER RESPONSE ACTIVITIES	**CITATION**	**REQUIREMENTS**	**CONSIDERATIONS**
	RCRA, Releases from Solid Waste Management Units; (Subpart F, 264.90-264.109)	The scope of the regulation encompasses: groundwater protection standards; concentration limits; point of compliance; compliance period; requirements for groundwater monitoring, detection monitoring, and compliance monitoring; and the corrective action program. Provides guidelines for the remediation of solid waste management units including: establishes specific groundwater monitoring requirements, sets MCLs as level of compliance for upper aquifer, and establishes requirements of the corrective action program.	Applicable to remedial alternatives that involve the closure and post-closure of SWMUs because BAAP holds a RCRA Part B Permit.
	RCRA, Hazardous Waste Permit Program; (40 CFR Part 270)	Establishes provisions covering basic USEPA permitting requirements.	RCRA permitting requirements need to be determined on a case-by-case basis, working with all involved regulatory agencies. However, any activity involving the treatment or containment of hazardous waste is subject to these permitting requirements.
Hazardous Waste Transportation	DOT Rule for Transportation of Hazardous Materials (49 CFR Parts 107, 171.1-172.558)	Outlines procedures for the packaging, labeling, manifesting, and transportation of hazardous materials.	This regulation will be applicable to any company contracted to transport hazardous wastes from the site.

continued

TABLE 2-5
POTENTIAL ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

POTENTIAL ACTION-SPECIFIC ARARS COMMON TO A VARIETY OF REMEDIAL ALTERNATIVES			
OTHER RESPONSE ACTIVITIES	CITATION	REQUIREMENTS	CONSIDERATIONS
	WDNR, Wisconsin Particulate and Sulfur Emissions Rules, Control of Particulate Emissions (WAC, Chapter NR 415)	This rule requires that precautions be taken to prevent particulate matter from becoming airborne. Particulate emission limits for certain processes are specified, and a default value of 0.4 lbs of particulate matter per 1,000 lbs of gas is established for any process not listed in Section 415.05. Particulate emission limits for fuel-burning equipment and incinerators are established.	Potential applicable requirements for off-site TSD units. Potential relevant and appropriate requirements for on-site TSD units.
	WDNR, Organic Compound Emission Rules (WAC, Chapter NR 419)	The rule states that no more than 5.7 liters of any liquid volatile organic compound (VOC) waste or any liquid, semisolid, or solid material containing more than 5.7 liters of any VOC may not be disposed of in one day's time from a facility in a manner which would permit evaporation into the ambient air during ozone season. The quantity of VOCs that evaporate into the ambient air during the ozone season must not exceed 15% (by weight) or 5.7 liters in any one day, whichever is larger.	Potential applicable requirements for off-site TSD units. Potential relevant and appropriate requirements for on-site TSD units.
	WDNR, Wisconsin Carbon, Lead, and Nitrogen Emission Rules (WAC, Chapters 426-428)	These rules establish emission rules for carbon, lead, and nitrogen.	Potential applicable requirements for off-site TSD units. Potential relevant and appropriate requirements for on-site TSD units.

continued

TABLE 2-5
POTENTIAL ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

POTENTIAL ACTION-SPECIFIC ARARs COMMON TO A VARIETY OF REMEDIAL ALTERNATIVES			
OTHER RESPONSE ACTIVITIES	CITATION	REQUIREMENTS	CONSIDERATIONS
	WDNR, General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404)	Primary and secondary ambient air quality standards for sulfur oxides, suspended particulated, carbon monoxide, ozone, nitrogen dioxide, lead, and particulate matter are established in this rule. The primary air standard provides protection for the public health with a margin of safety. The secondary air standard is the level of air quality that may be necessary to protect public welfare from unknown or anticipated adverse effects.	Same as above
	WDNR, Wisconsin Particulate and Sulfur Emissions Rules, Control of Particulate Emissions (WAC, Chapter NR 415)	This rule requires that precautions be taken to prevent particulate matter from becoming airborne. Particulate emission limits for certain processes are specified, and a default value of 0.4 lbs of particulate matter per 1,000 lbs of gas is established for any process not listed in Section 415.05. Particulate emission limits for fuel-burning equipment and incinerators are established.	Same as above.

continued

TABLE 2-5
POTENTIAL ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

POTENTIAL ACTION-SPECIFIC ARARS COMMON TO A VARIETY OF REMEDIAL ALTERNATIVES			
OTHER RESPONSE ACTIVITIES	**CITATION**	**REQUIREMENTS**	**CONSIDERATIONS**
Land Disposal	RCRA, Land Disposal Restrictions (LDRs); (40 CFR Part 268)	Land disposal of RCRA hazardous wastes without prior treatment is prohibited. Waste at specific sites must be evaluated as to whether it meets the definition of one of the specified restricted wastes and the remedial action must constitute "placement" for the land disposal restrictions to be considered applicable. For each hazardous waste, the LDRs specify that the waste must be treated either by a treatment technology or to a concentration level prior to disposal in a RCRA Subtitle C permitted facility.	Under the LDRs, treatment standards have been established for all listed wastes. If it is determined that hazardous wastes at BAAP are subject to LDRs, these requirements will be potential relevant and appropriate requirements for on-site disposal, and applicable requirements for off-site disposal.
	RCRA, Identification and Listing of Hazardous Waste; (40 CFR Part 261, 261.1-261.33)	Defines those solid wastes which are subject to regulation as hazardous wastes under 40 CFR Parts 262-265.	Applicability of RCRA regulations to wastes found at the site is dependent on the solid waste meeting one of the following criteria: a. Generated through a RCRA-listed source process. b. RCRA-listed waste from non-specific source. c. Characteristically hazardous due to ignitability, corrositivity, reactivity, or toxicity.
Worker Protection	Occupational Health and Safety Act (OSHA), Health and Safety Standards; (29 CFR Part 1926)	This regulation specifies the type of safety training, equipment, and procedures to be followed during site investigation and remediation.	All phases of the remedial response project at BAAP should be executed in compliance with this regulation.

continued

TABLE 2-5
POTENTIAL ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

REMEDIAL INVESTIGATION
BADGER ARMY AMMUNITION PLANT

POTENTIAL ACTION-SPECIFIC ARARS FOR SOIL TREATMENT AND DISPOSAL TECHNOLOGIES				
TECHNOLOGY	**DESCRIPTION**	**CITATION**	**REQUIREMENTS**	**CONSIDERATIONS**
Containment by Capping	Low-permeability cover is constructed over the site to provide a barrier to water infiltration and/or prevent direct contact and ingestion hazards associated with contaminated soil surfaces.	RCRA, 40 CFR 264.117(c)	Restrict post-closure use of property as necessary to prevent damage to the cover.	Because capping would not include placement of hazardous waste into another unit, this requirement is a potential applicable ARAR. Where "placement" occurs, the requirement is potentially relevant and appropriate.
		WDNR, Hazardous Waste Disposal Landfill Cap Standards; Chapter 660.15.	Specification for a final cover for hazardous waste landfills or surface impoundments which have operated without an operating license are established in this chapter.	These requirements are potential relevant and appropriate requirements for a capping system.
Excavation and Disposal in On-Site Landfill	Excavate and dispose of soils which are not regulated by RCRA LDRs in a secure on-site landfill constructed for that purpose.	RCRA, Landfills; (Subpart N, 264.300-261.339)	This regulation details the design, operation, monitoring, inspection, recordkeeping, closure, and permit requirements for a RCRA landfill.	For on-site disposal, these regulations are relevant and appropriate in order ensure adequate long-term land-based management of hazardous materials. For containment-oriented alternatives, the construction of caps using RCRA design and performance standards criteria may be warranted.

continued

TABLE 2-5
POTENTIAL ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

REMEDIAL INVESTIGATION
BADGER ARMY AMMUNITION PLANT

POTENTIAL ACTION-SPECIFIC ARARS FOR SOIL TREATMENT AND DISPOSAL TECHNOLOGIES				
TECHNOLOGY	**DESCRIPTION**	**CITATION**	**REQUIREMENTS**	**CONSIDERATIONS**
		Chapter NR 665; Wisconsin Hazardous Waste Incinerator Standards	This chapter establishes requirements and standards for incinerators that burn hazardous wastes. Requirements for design of the incinerator are outlined in Section NR 640.06.	The substantive requirements of this rule are potentially relevant and appropriate for on-site incineration of RCRA-regulated wastes.
		Also, see requirements listed under "Excavation" and "Air Emissions".		
Excavation and Treatment by Off-site Incineration	Excavate and treat soil by an incinerator which thermally destroys organics in a direct-fired treatment unit.	RCRA, Incinerators; (Subpart O, 264.340-264.599)	This regulation specifies the performance standards, operating requirements and monitoring, inspection, and closure guidelines of any incinerator burning hazardous waste.	These requirements are potential applicable or relevant and appropriate requirements for off-site incineration of RCRA-regulated wastes.
		Chapter NR 665; Wisconsin Hazardous Waste Incinerator Standards	This chapter establishes requirements and standards for incinerators that burn hazardous wastes. Requirements for design of the incinerator are outlined in Section NR 640.06.	The substantive requirements of this rule are potentially applicable or relevant and appropriate requirements for off-site incineration of RCRA-regulated wastes.
		See requirements listed under "Excavation", "Air Emissions", and "Hazardous Waste Transportation"		

continued

TABLE 2-5
POTENTIAL ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

REMEDIAL INVESTIGATION
BADGER ARMY AMMUNITION PLANT

POTENTIAL ACTION-SPECIFIC ARARS FOR SOIL TREATMENT AND DISPOSAL TECHNOLOGIES				
TECHNOLOGY	DESCRIPTION	CITATION	REQUIREMENTS	CONSIDERATIONS
Excavation and Treatment by Soil Washing	Excavate and mix soils with an aqueous-based washing solution in a series of high-energy mobile washing units. Organics and inorganics can be separated from soils with this system. Washing solution is recycled.	See requirements listed under "Excavation", "Hazardous Waste Transportation", and "Air Emissions".		
Excavation and Treatment by Soil Vitrification	Soils are excavated and heated to temperatures exceeding 2,000° C. Organic and nitrate chemical components are destroyed, the remaining contaminants are immobilized into a geologically stable glass material, and the overall volume of the waste is reduced.	See requirements listed under "Excavation", "Hazardous Waste Transportation", and "Air Emissions".		
Excavation and Treatment by Biodegradation/ Composting	Soils contaminated by organics are excavated and treated with engineered (rather than naturally occurring) biological decomposition under controlled conditions.	See requirements listed under "Excavation", "Hazardous Waste Transportation", and "Air Emissions".		

continued

TABLE 2-5
POTENTIAL ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

REMEDIAL INVESTIGATION
BADGER ARMY AMMUNITION PLANT

POTENTIAL ACTION-SPECIFIC ARARS FOR SOIL TREATMENT AND DISPOSAL TECHNOLOGIES				
TECHNOLOGY	DESCRIPTION	CITATION	REQUIREMENTS	CONSIDERATIONS
In-Situ Stabilization/ Solidification	A settling agent is placed with contaminated soil to form a monolithic product in which contaminants are entrapped by the solidified mass.	See requirements under "Air Emissions".		
In-Situ Bioventing	Air, nutrients, and moisture (as needed) are injected into a contaminated soil zone to enhance the indigenous microbe environment and increase the biodegradation rate of organic contaminants.	See requirements under "Air Emissions"		
In-Situ Biodegradation/ Composting	Soils contaminated by organics are treated in place with engineered (rather than naturally occurring) biological decomposition under controlled conditions.	See requirements under "Air Emissions".		

continued

TABLE 2-5
POTENTIAL ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ACTION-SPECIFIC ARARs FOR WATER TREATMENT AND DISPOSAL TECHNOLOGIES				
TECHNOLOGY	**DESCRIPTION**	**CITATION**	**REQUIREMENTS**	**CONSIDERATIONS**
Containment with Slurry Wall	Emplacement of a low permeability barrier to restrict groundwater migration. Should include a cover system to reduce infiltration.	RCRA - Land Disposal Restriction (40 CFR Part 268)	See requirements under "Land Disposal Restrictions".	Excavation of soil for construction of slurry wall may trigger LDRs. Materials subject to LDRs must therefore be placed in another unit.
Collection of Water into Groundwater Extraction Wells	Installation of several strategically located pumping wells to collect contaminated groundwater for treatment.	WDNR, Wisconsin Well Construction Standards, (WAC, Chapter NR 112)	This rule establishes standards and approvals for well construction. Any withdrawal well or combination of wells withdrawing more than 70 gpm or more is subject to this rule.	Any remedial alternative considered during the FS which proposes pumping of groundwater at a rate of greater than or equal to 70 gpm will consider this rule as a possible ARAR.
Treatment with UV/ Oxidation	Oxidize organic contaminants in extracted groundwater through simultaneous application of UV light and ozone or hydrogen peroxide.	See requirements under "Air Emissions".		
Treatment with Air Stripping	Reduce concentration of volatile organics through intimate contact of extracted groundwater with air. Water descends a packed column while air forced up the column to promote mass transfer of organics from aqueous to gaseous phase.	See requirements under "Air Emissions".		

continued

TABLE 2-5
POTENTIAL ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ACTION-SPECIFIC ARARs FOR WATER TREATMENT AND DISPOSAL TECHNOLOGIES				
TECHNOLOGY	**DESCRIPTION**	**CITATION**	**REQUIREMENTS**	**CONSIDERATIONS**
Discharge into Off-site Water Treatment Facility	Off-site disposal of extracted groundwater to a POTW. Groundwater would require transport by means of a force main and/or gravity feed sewer or by truck to the POTW.	CWA, National Pretreatment Standards; (40 CFR Part 403)	This regulation sets pretreatment standards for the introduction of pollutants from non-domestic sources into POTWs. These regulations are designed to control pollutants which pass through, cause interference, or are otherwise incompatible with treatment processes at a POTW.	If treated groundwater is discharged to a POTW, the discharge must meet all discharge limitations imposed by the POTW.
		Also, see requirements listed under "Transportation".		
Discharge by Groundwater Reinjection	Groundwater is reinjected using a series of wells and pumps. Can be used to enhance plume removal and accelerate remediation.	SDWA - Underground Injection Control Regulations; (40 CFR Parts 144, 146, 147, 1000)	These regulations outline minimum program and performance standards for underground injection programs.	State regulations prohibit discharge of water by reinjection wells.
		WDNR, Wisconsin Well Construction Standards, (WAC, Chapter NR 112)	In addition to establishing standards and approvals for well construction, this regulation prohibits the use of injection wells of any sort.	Because the state requirement is an enforceable requirement and more stringent than the federal requirements, it takes precedence of the federal requirement for remedies using reinjection wells.

Table 3-1
Human Health Contaminants of Concern
Propellant Burning Ground Soils

Feasibility Study
Badger Army Ammunition Plant

Compound of Potential Concern	Exposure Point Concentration	
	Surface Soil ($\mu g/g$)	Subsurface Soil ($\mu g/g$)
24DNT	10.7	58.9
26DNT	1	2
2MNAP	0.452	18.2
ANAPNE	-	16.9
ANAPYL	-	1.04
ANTRC	-	12.4
AS	9.45	18.8
B2EHP	6.2	6.2
BAANTR	0.204	8.9
BAPYR	-	3.55
BBFANT	-	3.91
BGHIPY	-	2.57
BKFANT	-	3.36
C6H6	0.42	9.09
CHRY	3.68	8.28
CR	49.8	40.4
CU	344	327.19
DBAHA	-	0.661
DBZFUR	-	5.8
DEP	6.2	6.2
DNBP	6.35	6.2
FANT	0.2	6.2
FLRENE	-	18.4
HG	0.334	-
ICDPYR	-	4.52
MEC6H5	-	1.04
NAP	-	6.2
NI	27.3	-
NIT	-	35
NNDPA	30.8	12
PB	2700	1200
PHANTR	1.32	12
PYR	0.168	6.2
SE	0.618	1.77

TABLE 3-2
CLEAN-UP STANDARDS
PROPELLANT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	SURFACE SOIL		SUBSURFACE SOIL	
	PROTECTION OF GROUNDWATER[1] (mg/kg)	PROTECTION OF HUMAN HEALTH[2] (mg/kg)	PROTECTION OF GROUNDWATER[1] (mg/kg)	PROTECTION OF HUMAN HEALTH[2] (mg/kg)
Organics				
24DNT	55	4.29	0.00002	4.29
26DNT	270	4.29	0.0002	4.29
2MNAP	NPAL	NHD	NPAL	NHD
ANAPNE	-	-	NPAL	62,580
ANAPYL	-	-	NPAL	41,720
ANTRC	-	-	NPAL	312,900
B2EHP	790,000	208.57	NI	208.57
CPAH[3]	NPAL	0.40	NPAL	0.40
BGHIPY	-	-	NPAL	41,720
C6H6	3,400	100.35	NI	100.35
DBZFUR	-	-	NPAL	NHD
DEP	NPAL	834,400	NPAL	834,400
DNBP	NPAL	NHD	NPAL	NHD
FANT	NPAL	41,720	NPAL	41,270
FLRENE	-	-	NPAL	41,270
MEC6H5	-	-	NI	208,537
NAP	-	-	NI	41,720
NNDPA	NI	595.92	NI	595.92
PHANTR	NPAL	41,720	NPAL	41,720
PYR	NPAL	31,290	NPAL	31,290
TRCLE	-	-	0.037	264.97
TXYLEN	-	-	NI	>1,000,000
Metals				
AS	0.080	1.6	0.068	1.6
CR	31.49	211.95	1.666	211.95
CU		38,591		38,591

TABLE 3-3
GROUNDWATER SUMMARY
PROPELLANT BURNING GROUND

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND OF POTENTIAL CONCERN	FREQUENCY OF DETECTION	MAXIMUM DETECTED CONCENTRATION (µg/L)	MINIMUM DETECTED CONCENTRATION (µg/L)	SDWA (1)		WI GROUNDWATER STANDARDS (2)		CALCULATED CONCENTRATION (3) (µg/L)
				MCL (µg/L)	MCLG (µg/L)	ES (µg/L)	PAL (µg/L)	
111TCE	14:94	59.3	2.52	200	200	200	40	-
26DNT	6:188	1.46	0.839	-	-	0.05	0.005	-
BA	70:70	130	24.1	2,000	2,000	2,000	400	-
BE	11:70	0.582	0.348	4	4	4(d)	0.4(d)	0.02
CCL4	123:197	108	1.86	5	0	5	0.5	-
CD	3:120	3.61	2.8	5	5	5	0.5	-
CHCL3	132:197	83.5	0.483	-	-	6	0.6	-
CL	187:187	140,000	2,400	250,000(a)	-	250,000(c)	125,000(c)	-
CR	57:120	46.6	4.93	100	100	100	10	-
CU	29:70	23.1	4.58	TT	1,300	1,300	130	-
HG	2:120	4.31	2.83	2	2	2	0.2	-
MN	9:70	1,700	11.2	50(a)	-	50(c)	25(c)	-
NA	48:70	94,000	2,090	20,000(b)	-	-	-	-
NIT	178:185	21,000	140	10,000	10,000	10,000	2,000	-
NNDPA	16:186	25	0.955	-	-	7(d)	0.7(d)	20
PB	18:120	13.6	5.54	TT	0	15	1.5	-
SO4	179:179	637,000	1.5	250,000(a)	-	250,000(c)	125,000(c)	-
TRCLE	124:197	117	0.329	5	0	5	0.5	-

Table 3-4
Ecological Contaminants of Concern
Propellant Burning Ground

Feasibility Study
Badger Army Ammunition Plant

Compound	Frequency	Exposure Point Concentration[A]
Surface Soil		
24DNT	16:114	10.7
2MNAP	2:13	0.452
AS	83:108	9.45
B2EHP	1:13	6.2
BAANTR	1:13	0.204
C6H6	8:114	0.42
CHRY	1:13	3.68
CR	108:108	49.8
CU	108:108	344
DEP	7:13	6.2
DNBP	4:13	6.35
FANT	2:13	0.2
HG	31:108	0.334
NI	108:108	27.3
NNDPA	3:13	30.8
PB	108:108	2,700
PHANTR	3:13	1.32
PYR	1:13	0.168
SE	10:108	0.618
ZN	108:108	1,040

Note:

[A] 95th percentile or maximum; units in micrograms per gram.

Full compound names are identified in the USAEC Chemical Code List located behind the Glossary of Acronyms

TABLE 3-6
REMEDIATION GOALS
PROPELLANT BURNING GROUND SURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	DETECTION LIMIT (mg/kg)	MAXIMUM DETECTED CONCENTRATION (mg/kg)	MAXIMUM BACKGROUND CONCENTRATION (mg/kg)	PROTECTION OF GROUNDWATER SOIL TARGET CONCENTRATION (mg/kg)	PROTECTION OF HUMAN HEALTH (mg/kg)	PROTECTION OF ECOLOGICAL RECEPTORS (mg/kg)	REMEDIATION GOAL (mg/kg)
24DNT	1.0	53.3	-	55	4.29	NR	4.29[1]
CPAH[3]	-	3.88	-	-	0.40	NR	0.40[1]
AS	0.1	64	16	0.080	1.6	NR	16[2]
CU	0.6	2,700	25	-	38,591	0.015	25[2]
HG	0.02	7.7	0.38	NLD	312.5	0.03	0.38[2]
PB	0.1	3,300	30	6.345	500	0.0054	30[2]
SE	0.2	2.03	0.70	0.0064	5,215	0.00045	0.70[2]
ZN	0.2	5,200	81.3	95.6	312,900	2.5	81.3[2]

Notes:

mg/kg = milligrams per kilogram
NR = Negligible risk to ecological receptors.
NLD = No leaching data for modeling.
[1] Protective of human health per NR 720 Rule.
[2] Background concentration; which is greater than NR 720 concentrations and/or ecological risk concentration.
[3] Carcinogenic PAHs; consisting of BAANTR and CHRY.

Full compound names are identified in the USAEC Chemical Code List located behind the Glossary of Acronyms

TABLE 3-8
REMEDIATION GOALS
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	MAXIMUM CONCENTRATION DETECTED (μg/L)	REMEDIATION GOAL (μg/L)	RATIONALE
CCL4	108	0.5	WPAL
CHCL3	83.5	0.6	WPAL
111TCE	59.3	40	WPAL
TRCLE	117	0.5	WPAL
26DNT	1.46	0.005	WPAL
NNDPA	25	0.7	Interim WPAL
BE	0.582	0.4	Interim WPAL
CR	46.6	10	WPAL
CD	3.61	0.5	WPAL
HG	4.31	0.2	WPAL
MN	1,700	25	WPAL[1]
PB	13.6	1.5	WPAL
SO4	637,000	125,000	WPAL[1]

Notes:

[1] Public welfare standards.
μg/L = micrograms per liter
WPAL = Wisconsin Preventive Action Limit

Full compound names are identified in the USAEC Chemical Code List located behind the Glossary of Acronyms

(continued)

TABLE 3-9
GENERAL RESPONSE ACTIONS AND POTENTIAL REMEDIAL TECHNOLOGIES
PROPELLANT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GENERAL RESPONSE ACTION	SOIL TECHNOLOGY	DESCRIPTION
Excavation/Treatment (cont.)	Anaerobic Thermal Process	Soil is excavated and treated by a mobile unit which volatilizes/desorbs VOCs/SVOCs from the soil and condenses them into a liquid stream.
	Soil Washing	Soil is excavated and mixed with an aqueous-based washing solution in a series of high-energy mobile washing units. VOCs/SVOCs and metals can be separated from soil with this system. Washing solution is recycled.
	Composting	Soil is excavated and mixed with amendment (cow manure, straw, and vegetable wastes) to prepare for composting. The mixture is placed in windrows and composted for several weeks. Final compost is backfilled into the excavated area.
In Situ Treatment	Soil Vapor Extraction	A vacuum is applied to vadose zone wells at the site to extract vapor from voids in the subsurface soil. The vapor is collected and either treated or released to the atmosphere.
	Stabilization/Solidification	Water and cement additives are mixed in place with contaminated soil to form a granular or monolithic product in which contaminants are entrapped by the solidified material.
	Soil Flushing	Aqueous-based washing solution is applied at the ground surface. Contaminants are removed from soil particles and held in the liquid phase as the solution infiltrates the soil. Solution containing the contaminants is removed through extraction wells after reaching the water table.
	Chemical-Biological	Chemical oxidants and nutrients are mixed into the soil to facilitate chemical and biological degradation of VOCs/SVOCs
	Bioventing	Air, nutrients, and moisture (as needed) are injected into a contaminated soil zone to enhance the indigenous microbe environment and increase the biodegradation rate of VOCs/SVOCs.

Notes:

RCRA = Resource Conservation and Recovery Act
SVOC = semivolatile organic compounds
VOC = volatile organic compounds

(continued)

TABLE 3-10
REMEDIAL TECHNOLOGY SCREENING
PROPELLANT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
On-Site Landfill	· No secondary wastes produced. · Contaminants may be relocated to a more stable, contained, lower exposure potential environment. · No transportation of waste over public roads.	· Would not reduce toxicity, or volume of contaminants. · RCRA Land Disposal Restrictions may limit wastes eligible for disposal. · Siting a landfill over an aquifer used as a drinking water source would be difficult. · Long-term monitoring and maintenance would be required. · Long-term liability associated with landfilled waste.	Eliminated	Obtaining regulatory approval of a landfill at BAAP would be difficult because of site geology (i.e., sandy soils) overlying an aquifer used as a drinking water source.
Off-Site Landfill	· Widely used and easily implemented technology. · No wastes/treatment residuals remaining on site. · Contaminants may be relocated to a more stable, contained, lower exposure potential environment. · Relatively little mobilization effort and cost. · Experienced excavation contractors available.	· Would not reduce toxicity or volume of contaminants. · RCRA Land Disposal Restrictions may limit wastes eligible for disposal. · Limited landfill capacity nationwide. · Transportation and landfilling costs may be expensive. · Long-term liability associated with landfilled wastes.	Retained	Could be used for direct disposal of soils or as an option for disposal of treatment residuals.
On-site Incineration	· Destruction and removal efficiencies greater than 99.99%, thus reducing volume of contaminants. · Technology is reliable and has been demonstrated for treating organics at full-scale. · Widely used for treatment of organics wastes. · Mobile units are available.	· Treatment of volatile metals (e.g., lead) collected by air pollution control equipment potentially required. · Treatment of inorganics remaining in soil potentially required. · Incineration of RCRA waste would require trial burns in order to receive permits to operate.	Retained	Capable of treating VOCs and SVOCs, both of which are present in waste pits at the PBG.
Off-Site Incineration	· Destruction and removal efficiencies greater than 99.99%, thus reducing volume of contaminants. · Technology is reliable and has been demonstrated for treating VOCs/ SVOCs at full-scale. · Widely used for treatment of VOC/ SVOC wastes. · Experienced vendors are available.	· Treatment of metals remaining in soil potentially required. · Limited capacity at RCRA-permitted incinerators. · High cost associated with transportation and incineration of wastes.	Retained	Capable of treating VOCs and SVOCs, both of which are present in waste pits at the PBG. May be cost-effective for treating small volumes of soil.

(continued)

TABLE 3-10
REMEDIAL TECHNOLOGY SCREENING
PROPELLANT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Soil Washing	• Demonstrated at full-scale for removal of metals from soil. • Wide application to varied waste groups. • Mobile units are available.	• Difficulty in treating complex waste mixtures. • Potentially hazardous chemicals may be brought on site to be used in process. • Potential difficulty in removing washing solution from treated soil. • Limited effectiveness for treating soil with high humic content and high fine-grained clay fraction.	Retained	Capable of treating metals contamination which is present in surface soil at the PBG, or SVOC contamination which is present in water pits at PBG.
Composting	• Demonstrated at full-scale for treatment of explosives-contaminated soil. • Widely used technology for organic wastes and does not require specialized operating personnel. • Minimal operating cost. • No side streams of waste generated. • Operating equipment easily available. • Treated soil can be used for backfilling.	• Treatability studies may be necessary for site-specific wastes. • Large quantity of soil amendment required.	Retained	Capable of treating explosives-contaminated soil which is present in waste pits at the PBG.
In Situ Vacuum Extraction	• Reduces mobility, toxicity, and volume of contaminants if vapors are collected and treated. • Effective for extraction of VOCs from unsaturated soil. • Demonstrated capability for extracting up to 2,000 lbs of VOCs per day. • Not subject to RCRA Land Disposal Restrictions. • Extraction equipment is off-the-shelf. • Experienced vendors are readily available.	• Vapors generally require treatment prior to discharge to the atmosphere. • Contaminants with low vapor pressure, such as DNTs, cannot be effectively removed. • Extensive soil and air monitoring required, including soil borings. • Treatment of metals remaining in soil potentially required. • Not effective for treating soil with a high moisture content.	Retained	Capable of extracting VOCs from contaminated subsurface soils, which are present in waste pits at the PBG.
In Situ Stabilization/ Solidification	• Technology has been demonstrated at full-scale for treating metals and VOCs/SVOCs. • Reduces mobility of metals and VOCs/ SVOCs. • Not subject to RCRA Land Disposal Restrictions.	• High concentrations of VOCs/ SVOCs may interfere with the setting agent. • Reagent/waste ratios are difficult to control. • Volume of contaminated media increased. • Verification of treatment can be difficult.	Retained	Capable of treating metals contamination which is present in surface soil at the PBG, or SVOC contamination which is present in waste pits at the PBG.

TABLE 3-11
REMEDIAL TECHNOLOGIES RETAINED FOR REMEDIAL ALTERNATIVES DEVELOPMENT
PROPELLANT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

			EXCAVATION/TREATMENT		
MINIMAL ACTION	CONTAINMENT	EXCAVATION/DISPOSAL	INORGANICS	ORGANICS	IN SITU TREATMENT
Institutional Controls/ Education Programs/ Site Fencing	Soil Cover Capping Slurry Wall	Off-Site Landfill	Stabilization/Solidification Soil Washing	On-Site Incineration Off-Site Incineration Composting	Vacuum Extraction Stabilization/Solidification Soil Flushing Chemical-Biological Bioventing

TABLE 3-12
GENERAL RESPONSE ACTIONS AND POTENTIAL REMEDIAL TECHNOLOGIES
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

General Response Action	Groundwater Technology	Description
In Situ Treatment	In Situ Biological	Introduce nutrients and oxygen or methane into the groundwater using a matrix of extraction wells and recirculation techniques.
Discharge	Off-Site Water Treatment Facility	Off-site disposal of extracted groundwater to a POTW. Groundwater would require transport by means of a force main and/or gravity feed sewer or by truck to the POTW.
	Groundwater Reinjection	Reinject treated groundwater using a series of wells and pumps. Can be used to enhance plume removal and accelerate remediation.
	Discharge to Surface Water	Discharge treated groundwater directly to nearby surface water body. Transport groundwater by means of force or gravity main.

Notes:
POTW = Publicly Owned Treatment Works
UV = ultraviolet
VOCs = Volatile Organic Compounds
SVOCs = Semivolatile Organic Compounds

(continued)

TABLE 3-13
REMEDIAL TECHNOLOGY SCREENING
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Air Stripping	· Treatment would reduce the volume of contaminants in groundwater. · Air Stripping is a proven and reliable technology for treatment of VOCs.	· Off-gases produced during remediation may require collection/ treatment/disposal. · Treatment is not effective for compounds with low volatility. · Pretreatment for the removal of inorganics required to prevent fouling of air-stripper system. · Post-treatment by carbon adsorption may be required to meet discharge limits.	Retained	Retained for treatment of VOCs in PBG groundwater.
Carbon Adsorption	· Treatment effectively removes organic material from groundwater by sorption. · Technology is reliable and has been demonstrated for treating VOCs/ SVOCs at full-scale. · Carbon adsorption could be implemented as a polishing step after air stripping to meet discharge requirements.	· Suspended solids may require removal prior to treatment to avoid clogging carbon bed. · Spent carbon from the adsorption process would require disposal or regeneration.	Retained	Retained for treatment of VOCs/ SVOCs in PBG groundwater.
Resin Adsorption	· Treatment would reduce the volume of chemicals in groundwater. · Removes VOCs/SVOCs and metals from the wastewater stream. · Capable of treating high flows.	· Process concentrates contaminants within the resin column, necessitating regeneration or disposal of the resin. · Reliability of this technology has not been demonstrated, particularly for groundwater treatment.	Retained	Retained for treatment of VOCs/ SVOCs in PBG groundwater.
In situ Biological Treatment	· Treatment would reduce volume, toxicity, and mobility of chemicals present in groundwater. · Contaminants are degraded to non-toxic compounds. · No air emissions or secondary waste streams are produced. · Recirculation equipment is off-the-shelf.	· Significant time and expense for laboratory degradation studies and field demonstrations. · Chlorinated VOCs/SVOCs (e.g., CCL4) can be difficult to treat. · Parameters (e.g., temperature, pH, nutrients, and oxygen) for optimal microorganism growth can be difficult to maintain. · Injection wells are susceptible to plugging by chemical precipitation of nutrients.	Retained	Retained for in situ treatment of VOCs/ SVOCs.
Off-Site Water Treatment Facility	· If sewer connection is nearby, this can be a relatively inexpensive discharge option.	· Approval by POTW, community and WDNR may be difficult	Eliminated	Discharge to surface water is the preferred option.

TABLE 3-14
REMEDIAL TECHNOLOGIES RETAINED FOR REMEDIAL ALTERNATIVES DEVELOPMENT
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

MINIMAL ACTION[1]	COLLECTION & TREATMENT[1]	IN-SITU TREATMENT[1]	DISCHARGE
Institutional Controls/ Education Programs	Groundwater Extraction Wells UV/Oxidation UV/Reduction Air Stripping Carbon Adsorption Resin Adsorption	Biological	Surface Water

Notes:

[1]Groundwater monitoring would be used in conjunction with these technologies.
UV = Ultraviolet

TABLE 3-16
DEVELOPMENT OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND SURFACE SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Remedial Action Objectives:

(1) Prevent concentrations of 24DNT, CPAH, AS, and PB in surface soil which exceed clean-up standards for protection of human health (developed and/or obtained from the proposed Chapter NR 720) from becoming available, either through incidental ingestion of soil or inhalation of particulates, to potential human receptors.

(2) Prevent concentrations of CU, HG, PB, SE, and ZN in surface soil that pose an unacceptable risk from becoming available, either through incidental ingestion or consumption of contaminated prey, to potential ecological receptors.

(3) Prevent concentrations of AS, PB, SE, and ZN in surface soil which exceed clean-up standards for protection of groundwater (developed from the proposed Chapter NR 720) from degrading groundwater quality in excess of WPALs.

(4) Prevent concentrations of DNTs in surface soil in WP-2 and WP-3 which exceed clean-up standards for protection of human health and groundwater (developed from the proposed Chapter NR 720) and/or pose an unacceptable risk to potential ecological receptors from becoming available to potential receptors or degrading groundwater quality.

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
PBG-SS1: Minimal Action	• Surround areas with fencing and post warning signs. • Institutional Controls. Implement zoning and deed restrictions to limit use of land within and around the site. • Education programs. • Groundwater monitoring. Perform water quality analyses to monitor contaminant migration and assess future environmental impacts. • Five-year site reviews.

(continued)

TABLE 3-16
DEVELOPMENT OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND SURFACE SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
PBG-SS4: Stabilization/Solidification and Soil Cover	• Mobilize stabilization/solidification equipment to site. • Excavate contaminated soil. • Confirmatory sampling to ensure wastes have been removed. • Transport and stockpile wastes at treatment area. • Stabilize/solidify contaminated soil. • Backfill excavations with treatment residuals and cover with soil. • Post-closure plan development to monitor, maintain, and inspect site. • Institutional Controls. Implement zoning and deed restrictions to protect the soil cover from invasive activities. • Groundwater monitoring. • Five-year site reviews.
PBG-SS5: Soil Washing	• Mobilize soil washing equipment to site. • Excavate contaminated soil. • Confirmatory sampling to ensure wastes have been removed. • Transport and stockpile wastes at treatment area. • Wash contaminated soil. • Transport secondary wastestreams (i.e., fines) off-site for treatment. • Backfill excavations with washed (i.e., clean) soil.

Table 3-17
Development of Remedial Alternatives
Propellant Burning Ground Subsurface Soils

Feasibility Study
Badger Army Ammunition Plant

Remedial Action Objectives:

(1) Prevent concentrations of 24DNT, 26DNT, CPAH, C6H6, AS, and PB in Landfill 1 and the 1949 Pit which exceed clean-up standards for protection of human health (developed and/or obtained from the proposed Chapter NR 720) from becoming available, either through incidental ingestion of soil or inhalation of particulates, to potential human receptors.

(2) Prevent concentrations of 24DNT, 26DNT, TRCLE, AS, CR, PB, SE, and ZN in Landfill 1 and the 1949 pit which exceed clean-up standards for protection of groundwater (developed from the proposed Chapter NR 720) from degrading groundwater quality in excess of WPALs.

Alternative	Description of Key Components
PBG-SB1: Minimal Action	• Institutional controls. Implement zoning and deed restrictions to prohibit invasive activities into Landfill 1 and the 1949 Pit. • Education programs. • Groundwater monitoring. Perform water quality analyses to monitor contaminant migration and assess future environmental impacts. • Five-year site reviews.
PBG-SB2: Capping	• Install RCRA caps to reduce leaching of contaminants to groundwater • Surface water management to minimize erosion of cover system. • Post-closure plan development to monitor, maintain, and inspect site. • Institutional Controls. Implement zoning and deed restrictions to protect the caps from invasive activities. • Groundwater monitoring. • Five-year site review.
PBG-SB3: Off-Site Landfill	• Excavate contaminated soil from Landfill 1 and the 1949 Pit. • Confirmatory sampling to confirm wastes have been removed. • Backfill excavation with clean fill. • Sample and analyze excavated soil to confirm it meets landfill acceptance criteria. • Transport soil to off-site landfill.

Notes:

Full compound names are identified in the USAEC Chemical Code List located behind the Glossary of Acronyms.

(continued)

TABLE 3-18
DEVELOPMENT OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
PBG-WP3: Off-Site Landfill and Capping	• Excavate WP-1 to approximately 30 feet bgs and WP-2 and WP-3 to approximately 15 feet bgs.[1] • Backfill excavations with clean fill. • Sample and analyze excavated soil to confirm it meets landfill acceptance criteria. • Transport soil to off-site landfill. • Install RCRA caps to reduce leaching of unexcavated contaminants to groundwater. • Post-closure plan development to monitor, maintain, and inspect site. • Institutional Controls. Implement zoning and deed restrictions to protect the caps from invasive activities. • Groundwater monitoring. • Five-year site reviews.
PBG-WP4: On-site Incineration and Capping	• Mobilize incinerator to site. • Excavate WP-1 to approximately 30 feet bgs and WP-2 and WP-3 to approximately 15 feet bgs[1]. • Transport and stockpile wastes at treatment area. • Incinerate soil. • Transport secondary waste streams off site for treatment. • Backfill excavations with treatment residuals. • Install RCRA caps to reduce leaching of unexcavated contaminants to groundwater. • Post-closure plan development to monitor, maintain, and inspect site.

(continued)

TABLE 3-18
DEVELOPMENT OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
PBG-WP6: Off-site Incineration and Capping	• Excavate WP-1 to approximately 30 feet bgs and WP-2 and WP-3 to approximately 15 feet bgs.[1] • Backfill excavation with clean fill. • Sample and analyze soil for incinerator-required parameters. • Transport soil to off-site incinerator. • Install RCRA caps to reduce potential risks associated with the leaching of unexcavated contaminants to groundwater. • Post-closure plan development to monitor, maintain, and inspect site. • Institutional Controls. Implement zoning and deed restrictions to protect the caps from invasive activities. • Groundwater monitoring. • Five-year site reviews.
PBG-WP7: In Situ Vacuum Extraction, Composting, and Capping	• Conduct tests to determine vapor concentrations and soil permeability to vapor flow. • Mobilize vacuum extraction equipment to the site. • Install vacuum extraction wells. • Extract volatile organics from soil. • Transport secondary waste streams off site for treatment. • Construct composting facility. • Excavate WP-1 approximately 30 feet bgs and WP-2 and WP-3 to approximately 15 feet bgs[1]. • Transport and stockpile untreated soil. • Screen soil to remove rocks.

(continued)

TABLE 3-18
DEVELOPMENT OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
PBG-WP8: In Situ Treatment (continued)	<u>Soil Flushing</u> • Install extraction wells within the confines of the slurry and grout barrier. • Mobilize soil flushing equipment to the site. • Irrigate waste pit soils with a continuous flow of flushing solution and pump resultant leachate from beneath the waste pits. • Treat extracted leachate at a groundwater treatment plant. • Confirmatory sampling from soil borings to ensure wastes have been removed. <u>Chemical-Biological</u> • Mobilize deep soil mixing equipment to the site. • Mix chemical oxidants into the soil using deep soil mixing equipment. • Mix nutrients into the soil using deep soil mixing equipment. • Continue mixing cycle until contaminant degradation is completed. • Confirmatory sampling from soil borings to ensure wastes have been destroyed.

(continued)

TABLE 3-18
DEVELOPMENT OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
PGB-WP11: In Situ Vacuum Extraction, Soil Washing, and Composting	• Conduct tests to determine vapor concentrations and soil permeability to vapor flow. • Mobilize vacuum extraction equipment to the site. • Install vacuum extraction wells. • Extract volatile organics from soil. • Transport secondary waste streams off site for treatment. • Construct retaining walls around waste pits to a depth of approximately 120 feet bgs. • Mobilize soil washing equipment to site. • Construct composting facility. • Excavate waste pits within confines of retaining walls. • Confirmatory sampling to ensure wastes have been removed. • Transport and stockpile wastes at soil washing treatment area. • Wash contaminated soil. • Backfill excavations with washed (i.e., clean) soil. • Transport secondary wastestreams (i.e., fines) to composting facility. • Add amendment (i.e., cow manure, straw, and vegetable wastes) to fines and blend together. • Place amended fines in windrows on asphalt pad in enclosure for composting. • Periodically turn the amended fines for temperature, humidity, and oxygen control. Add moisture as needed. • Backfill excavations with finished compost material.

TABLE 3-19
SCREENING OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND SURFACE SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative PBG-SS1: Minimal Action: This alternative consists of institutional controls, educational programs, groundwater monitoring, and five-year site reviews. Fencing and warning signs would surround those areas identified as posing a risk to human health.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Public access to affected areas would be restricted. • Low potential for exposure to contaminants during implementation. • Institutional controls would reduce the potential for future land development. • Educational programs would increase public awareness about contamination.	Advantages • Would be easy to implement because no soil remediation is required. • Services and material for fencing are readily available.	Advantages • Short-term cost for administration of institutional controls, educational programs, and groundwater monitoring and maintenance is relatively low.
Disadvantages • Would not reduce mobility, toxicity, or volume of contaminants. • Does not achieve remedial action objectives.	Disadvantages • Long-term monitoring and maintenance would be required.	Disadvantages • Future remedial actions may be more costly because contaminants would continue to migrate and contaminate greater volumes of soil. • Long-term liability associated with waste.

CONCLUSION: The minimal action alternative is **retained** as a baseline for comparison with the remaining alternatives for surface soils at the Propellant Burning Ground.

(continued)

TABLE 3-19
SCREENING OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND SURFACE SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative PBG-SS3: Off-Site Landfill: This alternative consists of excavating contaminated surface soil, backfilling excavations with clean fill, and transporting the contaminated soil off site for disposal in a landfill.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives. • Disposal of contaminants in a secure landfill. • No significant short-term or long-term threat to human health and the environment.	Advantages • Long-term monitoring and maintenance provided by host landfill. • Surface soils are easily and rapidly removed with conventional grading equipment. • Excavation and transportation services are readily available.	Advantages • No long-term costs associated with inspection, monitoring, and maintenance.
Disadvantages • Would not reduce the toxicity or volume of contaminants. • Without adequate health and safety practices, soil excavation could result in significant exposure of site workers to soil contaminants.	Disadvantages • Contaminated soil may fail TCLP analysis for PB, thus invoking RCRA Land Disposal Restrictions. • Contaminated soil which fails TCLP analysis for PB would be rejected by landfill unless it is first treated. • At least 60,000 YD^3 would be transported for disposal. • Capacity at RCRA-permitted landfills may be limited.	Disadvantages • Long-term liability associated with landfilled wastes. • High capital cost compared to containment and treatment alternatives.

CONCLUSION: This alternative includes transporting at least 60,000 YD^3 of soil to an off-site landfill. Considering that landfill capacity may be limited (particularly RCRA-permitted landfills) and the cost for transportation and disposal is prohibitively high, this alternative is **eliminated** from further consideration.

(continued)

TABLE 3-19
SCREENING OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND SURFACE SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative PBG-SS5: Soil Washing: This alternative consists of excavating contaminated soil, washing contaminated soil, and backfilling the excavations with the treated soil.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages	Advantages	Advantages
• Achieves remedial response objectives. • Effective for coarse-grained soil. • Reduces the volume of contaminated soil. • Off-site treatment of contaminated wastestream would reduce mobility of contaminants. • No long-term threat to human health and the environment.	• Soil washing is a proven, reliable technology for treating metals-contaminated soil. • Soil washing services are readily available. • No long-term monitoring and maintenance provisions. • Surface soils are easily and rapidly removed with conventional excavation equipment.	• No long-term costs associated with inspection, monitoring, and maintenance. • No long-term liability. • Low capital cost compared to the disposal alternative.
Disadvantages	Disadvantages	Disadvantages
• Would not reduce toxicity or mass of contaminants. • Without adequate health and safety practices, soil excavation, and treatment could result in significant exposure of site workers to soil contaminants.	• Contaminants may be difficult to remove from fine-grained soils such as loess. • The secondary wastestream may be a significant percentage of the original volume if the soil is primarily composed of fine-grained soils. • Fine soil particles are difficult to remove from the washing solution.	• Costs of treating the secondary waste stream could significantly increase overall cost.

CONCLUSION: Because the surface soil at the Propellant Burning Ground is topsoil and loess, soil washing may not result in significant volume reduction of contaminated soil. Therefore, this alternative is **eliminated** from further consideration.

TABLE 3-20
SUMMARY OF REMEDIAL ALTERNATIVES SCREENING
PROPELLANT BURNING GROUND SURFACE SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE		STATUS
Alternative PBG-SS1:	Minimal Action	Retained for detailed analysis.
Alternative PBG-SS2:	Soil Cover	Retained for detailed analysis.
Alternative PBG-SS3:	Off-Site Landfill	Eliminated from further consideration.
Alternative PBG-SS4:	Stabilization/Solidification and Soil Cover	Eliminated from further consideration.
Alternative PBG-SS5:	Soil Washing	Eliminated from further consideration.
Alternative PBG-SS6:	Modified In Situ Stabilization/Solidification and Soil Cover	Retained for detailed analysis.

TABLE 3-21
SCREENING OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND SUBSURFACE SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative PBG-SB2: Capping: This alternative consists of constructing multilayered caps over Landfill 1 and the 1949 Pit to prevent incidental soil ingestion and/or inhalation and to reduce infiltration. This alternative also includes institutional controls, groundwater monitoring, and five-year site reviews.

EFFECTIVENESS ADVANTAGES	IMPLEMENTABILITY ADVANTAGES	COST ADVANTAGES
Advantages • Potential for achieving remedial action objectives for protection of human health and groundwater. • Caps and institutional controls would reduce potential for exposure to contaminated soil in Landfill 1 and the 1949 Pit. • Caps would reduce leaching of metals from contaminated zone (i.e., 0 to 15 feet bgs) into groundwater. • Low potential for exposure to contaminants during implementation.	Advantages • Would be easy to implement. • Caps would require minimal maintenance for the short term. • Equipment, supplies, and vendors are readily available.	Advantages • Low capital cost compared to the disposal alternative.
Disadvantages • Would not reduce toxicity or volume of contaminants. • Caps may only be protective for the short term.	Disadvantages • Would require long-term monitoring and maintenance provisions.	Disadvantages • Long-term costs associated with inspection, monitoring, and maintenance. • Long-term liability associated with waste.

CONCLUSION: Because this alternative has potential for achieving the remedial action objectives for protection of human health and groundwater, and would be easily implemented, it is **retained** for detailed analysis.

TABLE 3-22
SUMMARY OF REMEDIAL ALTERNATIVES SCREENING
PROPELLANT BURNING GROUND SUBSURFACE SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	STATUS
Alternative PBG-SB1: Minimal Action	Retained for detailed analysis.
Alternative PBG-SB2: Capping	Retained for detailed analysis.
Alternative PBG-SB3: Off-Site Landfill	Retained for detailed analysis.

Table 3-23
Screening of Remedial Alternatives
Propellant Burning Ground Waste Pits

Feasibility Study
Badger Army Ammunition Plant

Alternative PBG-WP2: Capping: This alternative consists of constructing multilayered caps to prevent incidental soil ingestion and/or inhalation and to reduce infiltration. This alternative also includes institutional controls, groundwater monitoring, and five-year site reviews.

Effectiveness	**Implementability**	**Cost**
Advantages • Potential for achieving remedial action objectives for protection of human health. • Caps and institutional controls would reduce potential for exposure to contaminated surface soils at WP-2 and WP-3. • Low potential for exposure to contaminants during implementation. • Caps would reduce leaching of contaminants to groundwater.	Advantages • Would be easy to implement. • Caps would require minimal maintenance for the short-term. • Equipment, supplies, and vendors readily available.	Advantages • Low capital cost compared to disposal and treatment alternatives.
Disadvantages • Fails to achieve remedial action objective for protection of groundwater because VOCs would migrate laterally outside the caps by volatilization and into groundwater by infiltrating precipitation. • Would not reduce toxicity or volume of contaminants. • Caps may only be protective for the short term.	Disadvantages • Would require long-term monitoring and maintenance provisions. • Potential that caps may have to be removed in the future if source removal becomes necessary.	Disadvantages • Long-term costs associated with inspection, monitoring, and maintenance. • Long-term liability associated with waste.

CONCLUSION: Because this alternative is not expected to achieve remedial action objectives and does not reduce contaminant toxicity or volume, it is **eliminated** from further consideration.

(continued)

TABLE 3-23
SCREENING OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative PBG-WP4: On-Site Incineration and Capping: This alternative consists of excavating severely contaminated soil to a depth of approximately 30 feet below ground surface in WP-1 and approximately 15 feet below the bottom of WP-2 and WP-3, treating the soil by on-site incineration, backfilling the excavations with treated soil, and capping the sites. This alternative also includes institutional controls, groundwater monitoring, and five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives for protection of human health. • Remediation of upper 30 (15) feet of contaminated soil would eliminate incidental soil ingestion and inhalation hazards. • Soil remediation and caps would reduce contaminant mobility, toxicity, volume, and leaching of contaminants to groundwater.	Advantages • On-site incineration is a proven, reliable technology for treatment of organic contaminants. • On-site incineration services readily available. • Caps would require minimal maintenance for the short-term.	Advantages • None
Disadvantages • Potentially fails remedial action objective for protection of groundwater because VOCs in unexcavated soil may migrate laterally outside the caps by volatilization and into groundwater by infiltrating precipitation. • Caps may only be protective for the short term. • Without adequate health and safety practices, soil excavation and treatment could result in significant exposure of site workers to soil contaminants.	Disadvantages • Contaminated soil is expected to be RCRA-characteristic hazardous waste and trial burns would be required for an on-site incinerator. • Secondary wastestreams are generated. • Sheet piling or a 2:1 slope would be required to maintain an open pit during excavation. • Would require long-term monitoring and maintenance provisions.	Disadvantages • Long-term costs associated with inspection, monitoring, and maintenance. • Long-term liability associated with unexcavated wastes.

CONCLUSION: Because this alternative is protective of human health and reduces contaminant mobility, toxicity, and volume, it is **retained** for detailed analysis.

(continued)

TABLE 3-23
SCREENING OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative PBG-WP6: Off-Site Incineration and Capping: This alternative consists of excavating severely contaminated soil to a depth of approximately 30 feet below ground surface in WP-1 and approximately 15 feet below the bottoms of WP-2 and WP-3, backfilling excavations with clean fill, capping the sites, and transporting the contaminated soil to an off-site incinerator. This alternative also includes institutional controls, groundwater monitoring, and five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives for protection of human health. • Remediation of upper 30 (15) feet of contaminated soil would eliminate incidental soil ingestion and inhalation hazards. • Soil remediation and caps would reduce contaminant mobility, toxicity, and volume and the potential risks associated with the leaching of contaminants to groundwater.	Advantages • Off-site incineration is a proven, reliable technology for treatment of organic contaminants. • Excavation, transportation, and off-site incineration services are readily available. • Caps would require minimal maintenance for the short-term.	Advantages • None.
Disadvantages • Potentially fails remedial action objective for protection of groundwater because VOCs in unexcavated soil may migrate laterally outside the caps by volatilization and into groundwater by infiltrating precipitation. • Caps may only be protective for the short term. • Without adequate health and safety practices, soil excavation could result in significant exposure of site workers to soil contaminants.	Disadvantages • Soil remediation may be prolonged because of limited capacity at RCRA-permitted incinerators. • Sheet piling or a 2:1 slope would be required to maintain an open pit during excavation. • Would require long-term monitoring and maintenance provisions.	Disadvantages • High unit cost for off-site incineration (i.e., \$1,000-\$2,000 per ton) • Long-term costs associated with inspection, monitoring, and maintenance. • Long-term liability associated with unexcavated wastes.

CONCLUSION: Because of limited capacity at RCRA-permitted incinerators and the high cost for transportation and off-site incineration, this alternative is **eliminated** from further consideration.

(continued)

TABLE 3-23
SCREENING OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

<table>
<tr><td colspan="3">Alternative PBG-WP8: In Situ Treatment: This alternative consists of constructing a slurry and/or grout barrier completely enclosing the waste pits and either: (1) installing extraction wells within the perimeter of the slurry and/or grout barrier, applying flushing solutions at the ground surface to flush contaminants from soil, and collecting and treating leachate containing the flushed contaminants or (2) treating the soil in situ with chemical-biological.</td></tr>
<tr><th>EFFECTIVENESS</th><th>IMPLEMENTABILITY</th><th>COST</th></tr>
<tr><td>Advantages
• Potential for achieving remedial action objectives for protection of human health and groundwater.
• Would reduce the mobility, toxicity, and volume of contaminants after collection and treatment.
• Long-term leaching of contaminants to groundwater may be eliminated.
• Slurry and grout barrier would contain mobilized contaminants.
• Low potential for exposure to contaminants during implementation.</td><td>Advantages
• Not subject to RCRA Land Disposal Restrictions.
• Slurry and grout barrier construction services are readily available.
• Leachate from soil flushing could be treated at a BAAP groundwater treatment plant.
• Cover system construction not required.
• No long-term monitoring and maintenance provisions.</td><td>Advantages
• Low capital cost compared to excavate-and-treat alternatives.
• No long-term costs associated with inspection, monitoring, and maintenance.
• Minimize long-term liability.</td></tr>
<tr><td>Disadvantages
• Potential for groundwater contamination if the slurry and grout barrier fails to contain leachate.</td><td>Disadvantages
• Soil flushing not proven with DNT-contaminated soil.
• Chemical-biological not proven with DNT-contaminated soil.
• Extensive modeling and testing required to ensure containment and collection of mobilized contaminants.
• Extensive treatability studies to select best treatment method.
• Confirmatory subsurface soil sampling required to verify removal/destruction of contaminants.</td><td>Disadvantages
• Indefinite treatment costs.
• Potentially significant treatability study costs.
• Potentially high confirmatory sampling costs.</td></tr>
</table>

CONCLUSION: Because this alternative has potential for achieving remedial action objectives for protection of human health and groundwater without excavation of contaminated soil, and includes treatment of contaminated soil, it is **retained** for detailed analysis.

(continued)

TABLE 3-23
SCREENING OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative PBG-WP10: On-Site Incineration: This alternative consists of excavating contaminated soil to the limit of soil contamination (i.e., approximately 100 feet below ground surface in WP-1 and an undetermined depth in WP-2 and WP-3), treating the soil by on-site incineration, and backfilling the excavations with treated soil.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives for protection of human health and groundwater. • Would reduce the mobility, toxicity, and volume of contaminants. • Long-term leaching of contaminants would be eliminated.	Advantages • Retaining wall technologies have been demonstrated for excavations of similar depth. • On-site incineration is a proven, reliable technology for treatment of organic contaminants. • On-site incineration services readily available. • Cover system construction not required. • No long-term monitoring and maintenance provisions.	Advantages • No long-term costs associated with inspection, monitoring, and maintenance. • Minimizes long-term liability.
Disadvantages • Without adequate health and safety practices, soil excavation, and treatment could result in significant exposure of site workers to soil contaminants.	Disadvantages • Extensive geotechnical investigations of site conditions would be required for retaining wall design. • Contaminated soil is expected to be RCRA-characteristic hazardous waste and trial burns would be required for an on-site incinerator. • Secondary wastestreams are generated.	Disadvantages • High capital cost compared to all other alternatives.

CONCLUSION: Because this alternative achieves remedial action objectives and includes permanent treatment of contaminated soil, it is **retained** for detailed analysis.

(continued)

TABLE 3-23
SCREENING OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative PBG-WP12: In Situ Stabilization/Solidification and Soil Cover: This alternative consists of in situ stabilization/solidification to the limit of soil contamination (i.e., approximately 100 feet below ground surface in WP-1 and an undetermined depth in WP-2 and WP-3) using specialized deep mixing auger assemblies. This alternative also includes a soil cover, institutional controls, groundwater monitoring, and five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objective for protection of human health. • Contaminants in the treatment residuals are unavailable to human receptors. • Potential for achieving remedial action objective for protection of groundwater. • Contaminants in the treatment residuals are potentially isolated from infiltrating precipitation. • Would reduce the potential mobility of contaminants. • Low potential for exposure to contaminants during implementation.	Advantages • Not subject to RCRA Land Disposal Restrictions. • Contaminated soil is within design depth capability of deep mixing equipment.	Advantages • Low capital cost compared to excavate-and-treat alternatives

TABLE 3-24
SUMMARY OF REMEDIAL ALTERNATIVES SCREENING
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE		STATUS
Alternative PBG-WP1:	Minimal Action	Retained for detailed analysis.
Alternative PBG-WP2:	Capping	Eliminated from further consideration.
Alternative PBG-WP3:	Off-Site Landfill and Capping	Eliminated from further consideration.
Alternative PBG-WP4:	On-Site Incineration and Capping	Retained for detailed analysis.
Alternative PBG-WP5:	Composting and Capping	Retained for detailed analysis.
Alternative PBG-WP6:	Off-Site Incineration and Capping	Eliminated from further consideration.
Alternative PBG-WP7:	In Situ Vacuum Extraction, Composting, and Capping	Retained for detailed analysis.
Alternative PBG-WP8:	In Situ Treatment	Retained for detailed analysis.
Alternative PBG-WP9:	In Situ Vacuum Extraction and Bioventing	Eliminated from further consideration.
Alternative PBG-WP10:	On-Site Incineration	Retained for detailed analysis.
Alternative PBG-WP11:	In Situ Vacuum Extraction, Soil Washing, and Composting	Retained for detailed analysis.
Alternative PBG-WP12:	In Situ Stabilization/ Solidification and Soil Cover	Eliminated from further consideration.

Table 3-26
Development of Remedial Alternatives
Propellant Burning Ground Groundwater

Feasibility Study
Badger Army Ammunition Plant

Remedial Action Objective:

(1) Prevent further migration of contaminated groundwater.
(2) Reduce the concentrations of CCL4, 26DNT, CHCL3, TRCLE, 111TCE, CR, PB, CD, and HG to their respective WPALs.
(3) Reduce the concentrations of BE and NNDPA to their respective interim WPALs.
(4) Reduce the concentrations of MN and SO4 to a level at or below the public welfare standards.

Alternative	Description of Key Components
PBG-GW1: Minimal Action	• Institutional Controls. Implement zoning and deed restrictions to prohibit use of groundwater within and around the site. • Education programs. • Groundwater Monitoring. Perform water quality analyses to monitor contaminant migration and assess future environmental impacts. • Five-year site reviews.
PBG-GW2: IRM and Carbon Adsorption	• Install groundwater extraction system. • Construct carbon adsorption treatment facility. • Groundwater extracted and treated in the IRM facility and the new facility. • Treated water discharged to Lake Wisconsin. • Effluent monitored as required by WDNR permit requirements. • Groundwater monitoring. Water quality analyses performed to monitor progress cleanup. • Periodic reviews.
PBG-GW3: IRM and UV/Oxidation - Air Stripping	• Install groundwater extraction system. • Construct UV/oxidation - air stripping treatment facility. • Extract groundwater and treat in the IRM facility and the new facility. • Discharge treated water to Lake Wisconsin. • Monitor effluent as required by WDNR permit requirements. • Groundwater monitoring. Perform water quality analyses to monitor cleanup progress. • Five-year site reviews.

TABLE 3-26
DEVELOPMENT OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
PBG-GW7: IRM and UV/Reduction - Carbon Adsorption	• Install groundwater extraction system. • Construct UV/reduction - carbon adsorption treatment facility. • Extract groundwater and treat in the IRM facility and the new facility. • Discharge treated water to Lake Wisconsin. • Monitor effluent as required by WDNR permit requirements. • Groundwater monitoring. Perform water quality analyses to monitor cleanup progress. • Five-year site reviews.

Notes:

UV = ultraviolet
WDNR = Wisconsin Department of Natural Resources
WES = Wisconsin Enforcement Standard
IRM = Interim Remedial Measure
WPAL = Wisconsin Preventive Action Limits

Full compound names are identified in the USAEC Chemical Code List located behind the Glossary of Acronyms.

(continued)

TABLE 3-27
SCREENING OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative PBG-GW2: IRM and Carbon Adsorption: This alternative consists of continued operation of the IRM facility and construction and operation of a carbon adsorption treatment facility. This alternative includes groundwater extraction, treatment, effluent monitoring, discharge to Lake Wisconsin, groundwater monitoring, and periodic reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages	Advantages	Advantages
• Achieves remedial action objectives. • Extraction system would capture the PBG plume. • Reduces the mobility of groundwater contaminants. • Off-site thermal reactivation of spent carbon destroys contaminants.	• Performance of carbon adsorption is well documented. • Treatability studies not required. • Carbon adsorption system components are easy to install and relatively simple to operate. • If the source of groundwater contamination is removed, long-term (i.e., the period after remedial action objectives for groundwater have been attained) monitoring and maintenance provisions would not be required.	• Potentially low capital cost.
Disadvantages	Disadvantages	Disadvantages
• Produces a large volume of treatment residuals which must be transported and treated off site.	• Spent carbon from the process requires off-site treatment.	• Significant short-term (i.e., during groundwater remediation) costs associated with monitoring program for groundwater quality and treatment facility discharge. • Potentially high operating cost associated with purchase of new carbon for every change-out.

CONCLUSION: Because carbon adsorption is a demonstrated technology and it is easily implemented, this alternative is **retained** for detailed analysis.

Table 3-27
Screening of Remedial Alternatives
Propellant Burning Ground Groundwater

Feasibility Study
Badger Army Ammunition Plant

Alternative PBG-GW4: IRM and Air Stripping - Carbon Adsorption: This alternative consists of continued operation of the IRM facility and construction and operation of an air stripping - carbon adsorption facility. This alternative includes groundwater extraction, treatment, effluent monitoring, discharge to Lake Wisconsin, groundwater monitoring, and five-year site reviews.

Effectiveness	Implementability	Cost
Advantages	Advantages	Advantages
• Achieves remedial action objectives. • Extraction system would capture the PBG plume. • Reduces the mobility of groundwater contaminants. • Air stripping is efficient for treatment of principal groundwater contaminants. • Carbon adsorption has the capability of removing contaminants that pass through air stripper.	• Performance of air stripper and carbon adsorption units is well documented. • Experienced vendors are available to provide equipment and services. • Systems can accommodate a range of flow rates.	• Capital and operation and maintenance costs are comparable to other water treatment processes.
Disadvantages	Disadvantages	Disadvantages
• Treatment residuals must be transported and treated off-site.	• May require pretreatment for suspended solids, carbonate/ bicarbonates, and/or metals to prevent fouling of air stripper packing and/or carbon. • Treatment (e.g., vapor-phase carbon) may be required for air stripper emissions. • Spent carbon from the process requires off-site treatment.	• Significant short-term (i.e., during groundwater remediation) costs associated with monitoring program for groundwater quality and treatment facility discharge.

CONCLUSION: Because this alternative achieves remedial action objectives and includes efficient treatment of groundwater contaminants, it is **retained** for detailed analysis.

(continued)

TABLE 3-27
SCREENING OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative PBG-GW6: In Situ Biological: This alternative consists of in situ biological treatment, groundwater monitoring, and five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages	Advantages	Advantages
• Potential for achieving remedial action objectives. • Reduces the mobility, toxicity, and volume of contaminants. • Limited potential for exposure to contaminants during implementation.	• No secondary waste streams or air emissions. • Off-the-shelf equipment simplifies implementation. • Aquifer underlying the PBG is homogeneous and has high permeability, physical conditions which favor this alternative.	• Capital and operation and maintenance costs could be significantly less than those for conventional pump and treat technologies.
Disadvantages	Disadvantages	Disadvantages
• Chlorinated organics, especially CCL4, are resistant to biodegradation, and microorganisms indigenous to aquifer may not be capable of degrading PBG groundwater contaminants. • Recirculation system would not contain plume and groundwater contamination would continue to migrate off site during treatment.	• Demonstrated performance for full-scale treatment of chlorinated organics is limited. • Degradation studies are necessary to determine nutrient, oxygen or methane requirements. • Extensive testing is required to determine suitability of aquifer for supporting remediation by biodegradation.	• Significant costs associated with laboratory testing and field demonstrations.

CONCLUSION: Because in situ biological treatment is not a demonstrated technology for remediation of PBG groundwater contaminants, and groundwater contamination would continue to migrate off site during remediation, this alternative is **eliminated** from further consideration.

TABLE 3-28
SUMMARY OF REMEDIAL ALTERNATIVES SCREENING
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	STATUS
Alternative PBG-GW1: Minimal Action	Retained for detailed analysis.
Alternative PBG-GW2: IRM and Carbon Adsorption	Retained for detailed analysis.
Alternative PBG-GW3: IRM and UV/Oxidation-Air Stripping	Eliminated from further consideration.
Alternative PBG-GW4: IRM and Air Stripping-Carbon Adsorption	Retained for detailed analysis.
Alternative PBG-GW5: IRM and Resin Adsorption	Retained for detailed analysis.
Alternative PBG-GW6: In Situ Biological	Eliminated from further consideration.
Alternative PBG-GW7: IRM and UV/Reduction-Carbon Adsorption	Retained for detailed analysis.

Notes:

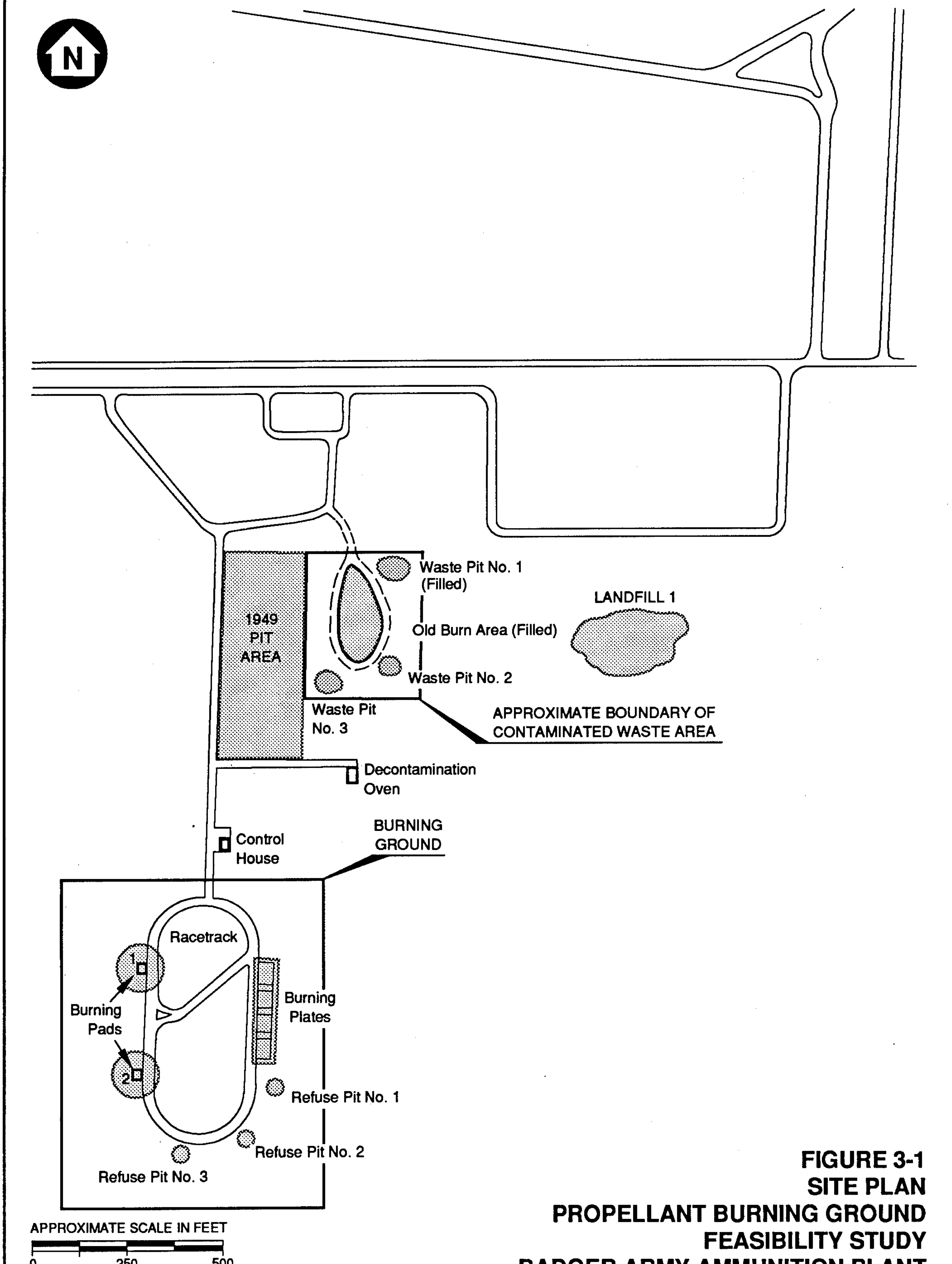
UV = Ultraviolet

(continued)

TABLE 3-29
SUMMARY OF CONTAMINATION ASSESSMENT
THROUGH REMEDIAL ALTERNATIVES SCREENING
PROPELLANT BURNING GROUND

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

RI/FS COMPONENT	CONTAMINATED MEDIA AT THE PROPELLANT BURNING GROUND		
	SURFACE SOIL	SUBSURFACE SOIL	GROUNDWATER
Remedial Technologies Retained After Screening	• Soil Cover • Off-Site Landfill • Stabilization/Solidification • Soil Washing • In Situ Stabilization/ Solidification	1949 Pit and Old Landfill: • Capping • Off-Site Landfill Waste Pits: • Capping • Off-Site Landfill • Slurry Wall • Soil Washing • On- and Off-Site Incineration • In Situ Vacuum Extraction • In Situ Stabilization/ Solidification • Soil Flushing • Chemical-Biological • Bioventing • Composting	• Groundwater Extraction Wells • UV/Oxidation • Air Stripping • UV/Reduction • Carbon Adsorption • Resin Adsorption • In-Situ Biological • Surface Water Discharge
Remedial Alternatives Developed	• Minimal Action • Soil Cover • Off-Site Landfill • Stabilization/Solidification and Soil Cover • Soil Washing • Modified In Situ Stabilization/Solidification and Soil Cover	1949 Pit and Old Landfill: • Minimal Action • Capping • Off-Site Landfill Waste Pits: • Minimal Action • Capping • Off-Site Landfill and Capping • On-Site Incineration and Capping • Off-Site Incineration and Capping • In-Situ Vacuum Extraction, Composting, and Capping • In Situ Treatment • In Situ Vacuum Extraction and Bioventing • On-Site Incineration • In Situ Vacuum Extraction, Soil Washing, and Composting • In Situ Stabilization/ Solidification and Soil Cover	• Minimal Action • Existing Conditions • IRM and UV/Oxidation, Air Stripping • IRM and Air Stripping, Carbon Adsorption, Discharge • IRM and Resin Adsorption • In-Situ Biological • IRM and UV/Reduction, Carbon Adsorption

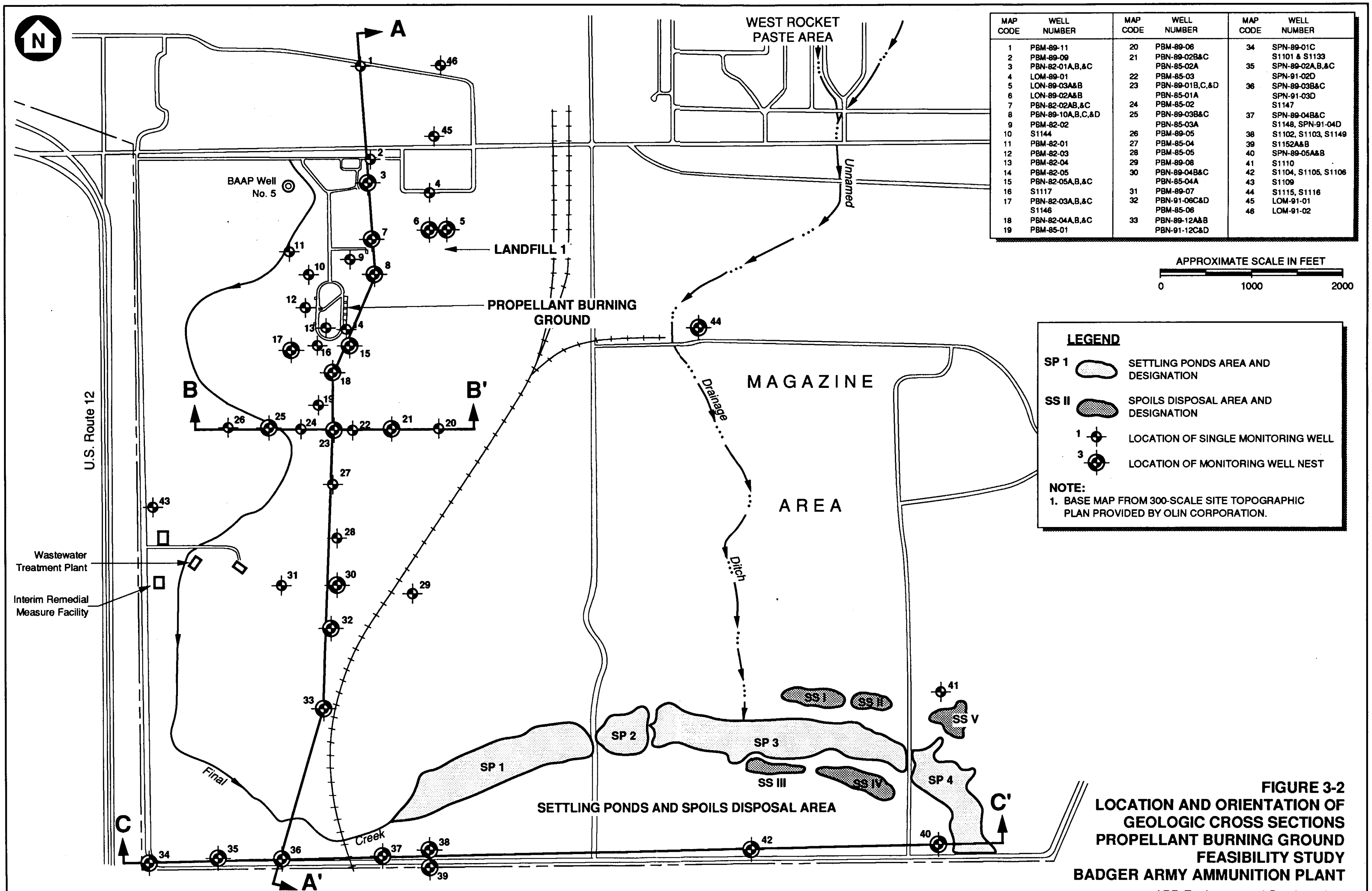


Source: Modified from Tsai, et.al., 1988.

FIGURE 3-1
SITE PLAN
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9211044D12



MAP CODE	WELL NUMBER	MAP CODE	WELL NUMBER	MAP CODE	WELL NUMBER
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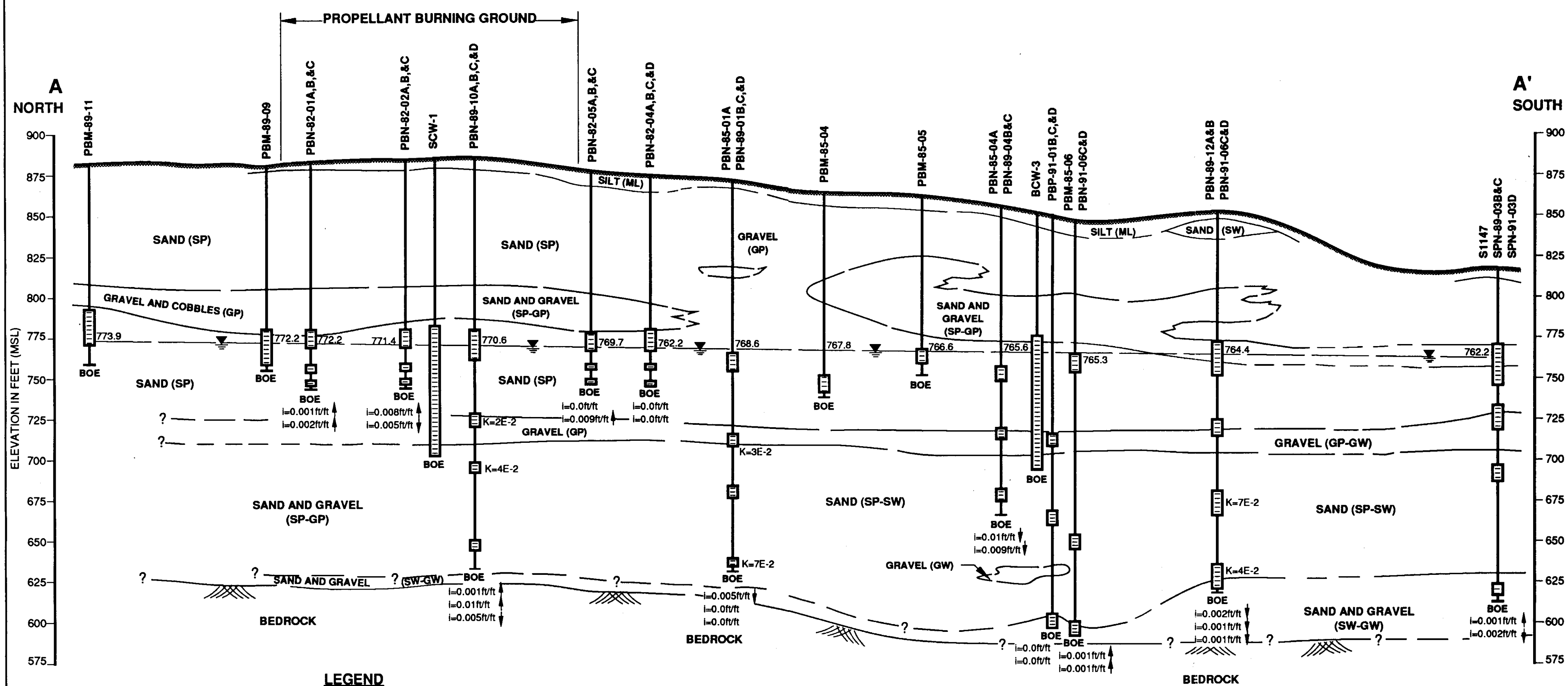
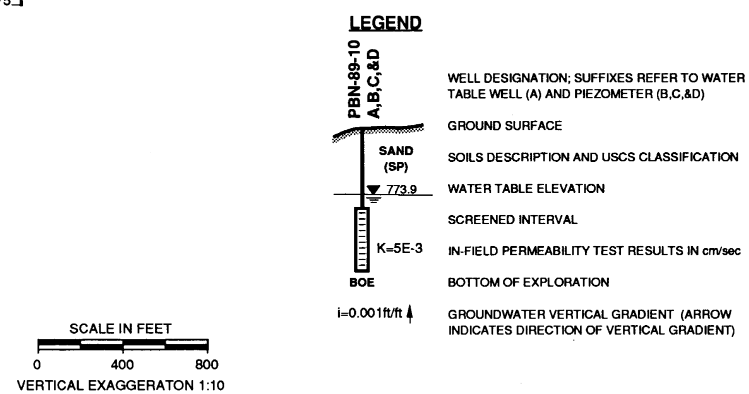
2	PBM-89-09	21	PBN-89-02B&C		S1101 & S1133
3	PBN-82-01A,B,&C		PBN-85-02A	35	SPN-89-02A,B,&C
4	LOM-89-01	22	PBM-85-03		SPN-91-02D
5	LON-89-03A&B	23	PBN-89-01B,C,&D	36	SPN-89-03B&C
6	LON-89-02A&B		PBN-85-01A		SPN-91-03D
7	PBN-82-02AB,&C	24	PBM-85-02		S1147
8	PBN-89-10A,B,C,&D	25	PBN-89-03B&C	37	SPN-89-04B&C
9	PBM-82-02		PBN-85-03A		S1148, SPN-91-04D
10	S1144	26	PBM-89-05	38	S1102, S1103, S1149
11	PBM-82-01	27	PBM-85-04	39	S1152A&B
12	PBM-82-03	28	PBM-85-05	40	SPN-89-05A&B
13	PBM-82-04	29	PBM-89-08	41	S1110
14	PBM-82-05	30	PBN-89-04B&C	42	S1104, S1105, S1106
15	PBN-82-05A,B,&C		PBN-85-04A	43	S1109
16	S1117	31	PBM-89-07	44	S1115, S1116
17	PBN-82-03A,B,&C	32	PBN-91-06C&D	45	LOM-91-01
	S1146		PBM-85-06	46	LOM-91-02
18	PBN-82-04A,B,&C	33	PBN-89-12A&B		
19	PBM-85-01		PBN-91-12C&D		

FIGURE 3-2
LOCATION AND ORIENTATION OF GEOLOGIC CROSS SECTIONS
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9211045D cd





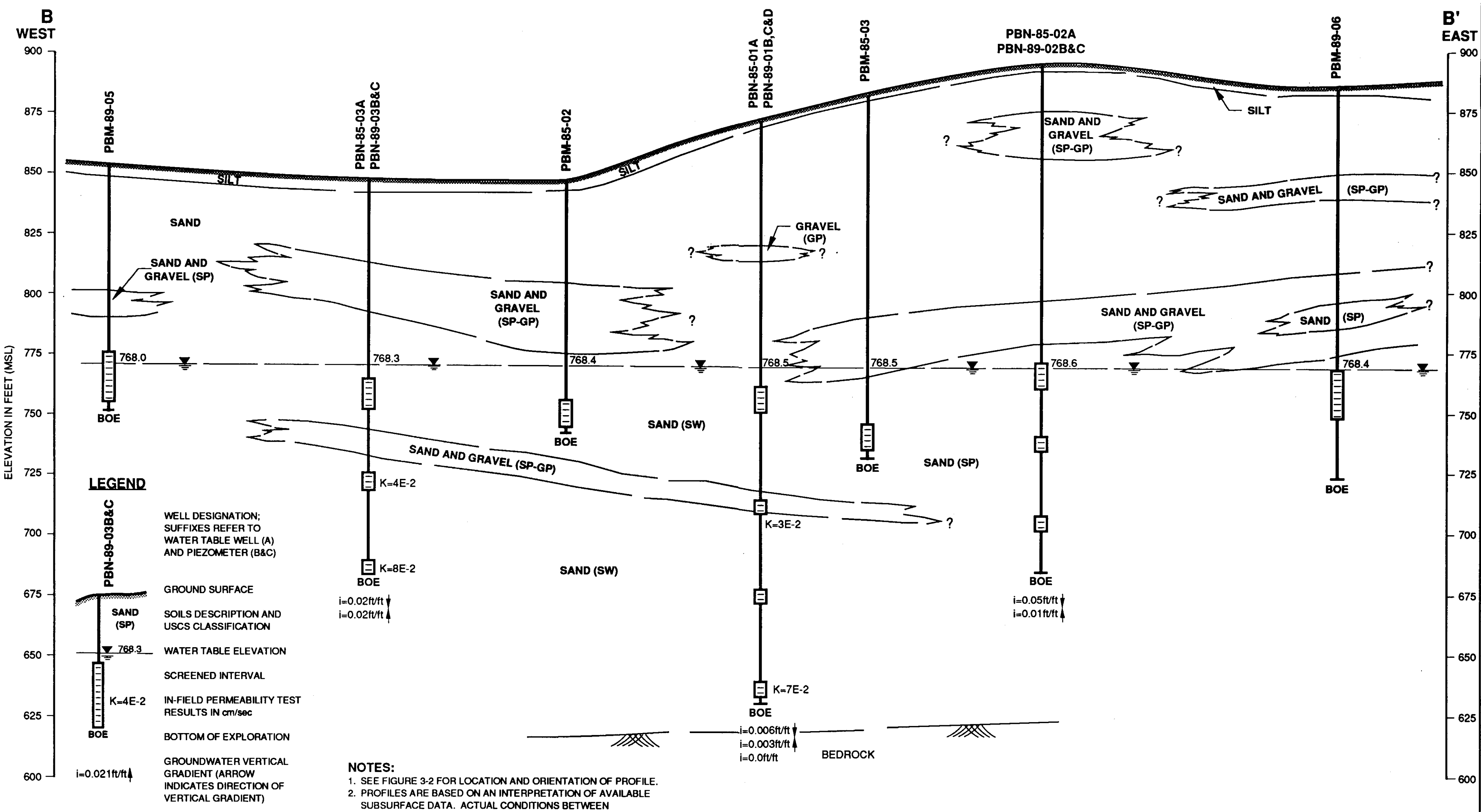
NOTES:

1. SEE FIGURE 3-2 FOR LOCATION AND ORIENTATION OF PROFILE.
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA. ACTUAL CONDITIONS BETWEEN EXPLORATIONS MAY VARY FROM THOSE SHOWN.
3. ON MULTIPLE WELL NESTS, GRADIENTS ARE LISTED IN ORDER OF SHALLOW TO DEEP WELLS; i.e., A TO B, B TO C AND C TO D.
4. WATER LEVELS MEASURED IN WATER TABLE WELLS ON 12/15/91 ARE LISTED.
5. BEDROCK SURFACE ELEVATION ESTIMATED FROM PBB-89-10 AND PRODUCTION WELL NO. 5.
6. BEDROCK SURFACE ELEVATION ESTIMATED FROM PBN-89-12D (LOCATED ADJACENT TO PBN-89-10), SPN-91-04D (LOCATED APPROXIMATELY 1200 FEET EAST OF SPN-91-03D), AND PRODUCTION WELL NO. 5 (LOCATED APPROXIMATELY 1000 FEET NORTH OF PBN-89-10).
7. PBP-91-01B,C,&D IS USED ONLY FOR GEOLOGIC INFORMATION AND AQUIFER ANALYSIS. IT IS NOT A MONITORING WELL CLUSTER.

FIGURE 3-3
GEOLOGIC CROSS SECTION A-A'
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9305003D



NOTES:

1. SEE FIGURE 3-2 FOR LOCATION AND ORIENTATION OF PROFILE.
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA. ACTUAL CONDITIONS BETWEEN EXPLORATIONS MAY VARY FROM THOSE SHOWN.
3. ON MULTIPLE WELL NESTS, GRADIENTS ARE LISTED IN ORDER OF SHALLOW TO DEEP WELLS; i.e., A TO B, B TO C AND C TO D.
4. WATER LEVELS MEASURED IN WATER TABLE WELLS ON 12/15/91 ARE LISTED.
5. BEDROCK SURFACE ELEVATION ESTIMATED FROM PBB-89-10 AND PRODUCTION WELL NO. 5.

SCALE IN FEET

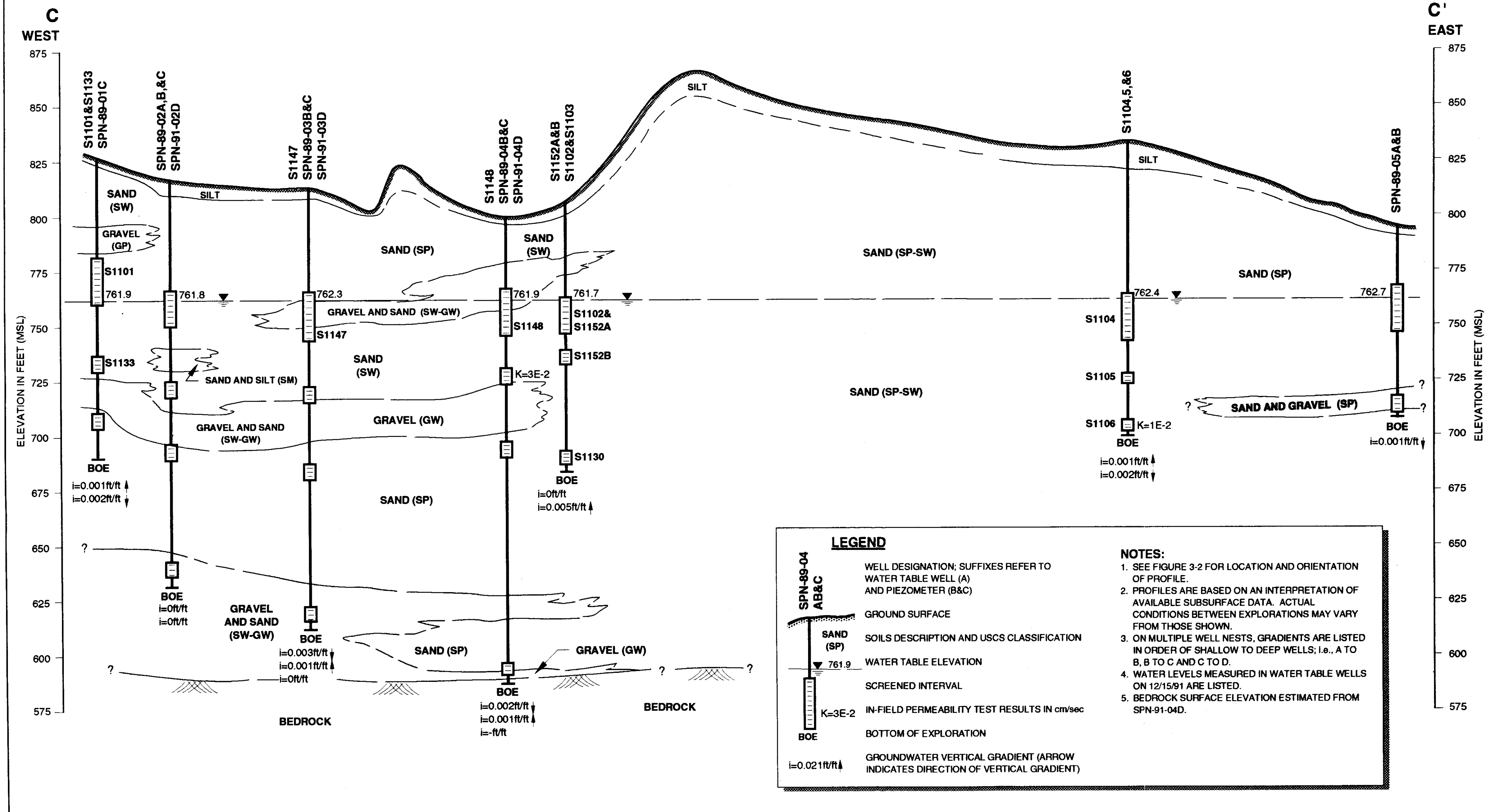
0 200 400

VERTICAL EXAGGERATON 1:5

FIGURE 3-4
GEOLOGIC CROSS SECTION B-B'
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9305008D1

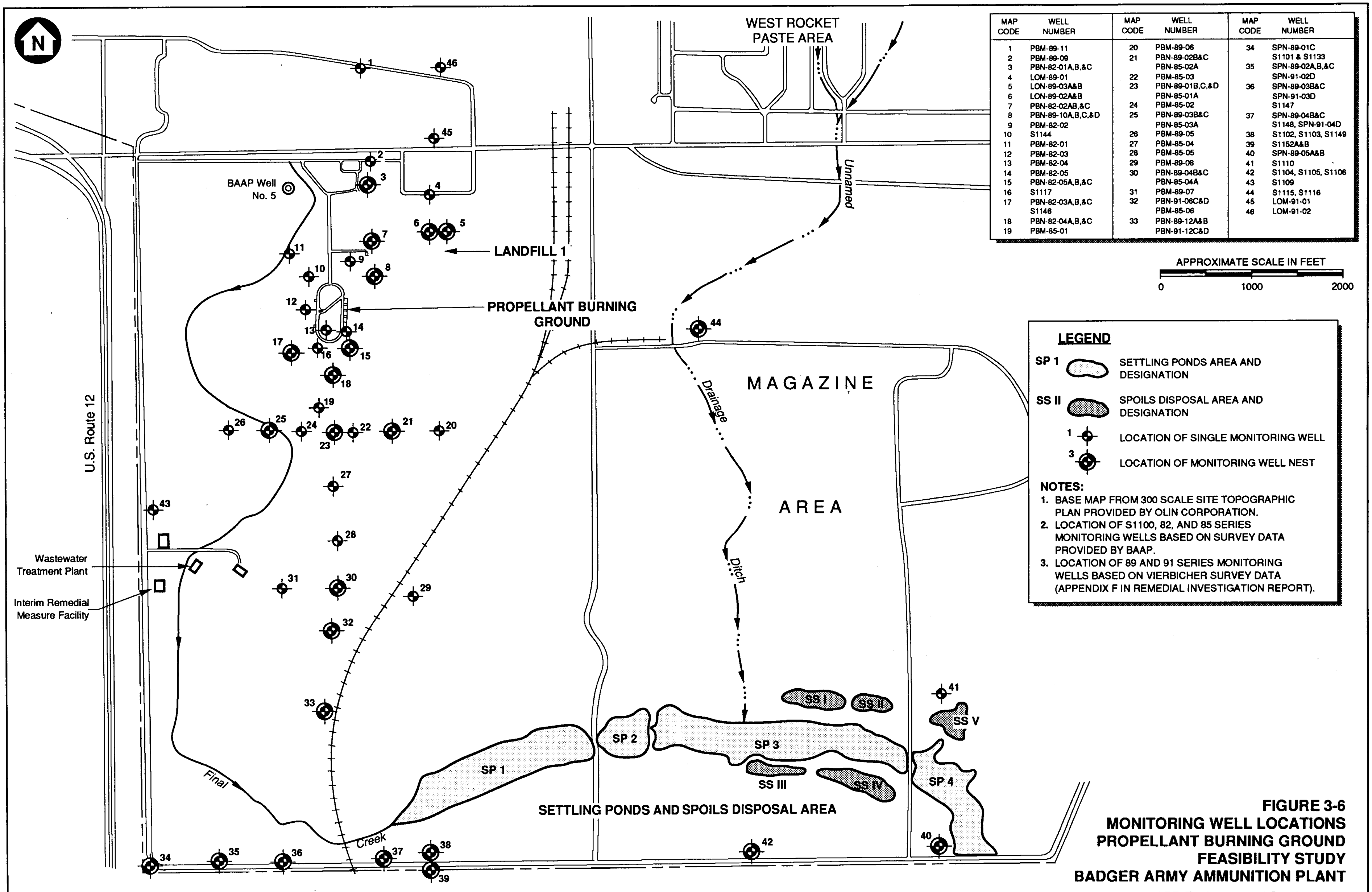


SCALE IN FEET
0 600 1200
VERTICAL EXAGGERATON 1:5

FIGURE 3-5
GEOLOGIC CROSS SECTION C-C'
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9305009D1



MAP CODE	WELL NUMBER	MAP CODE	WELL NUMBER	MAP CODE	WELL NUMBER
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2	PBM-89-09	21	PBN-89-02B&C		S1101 & S1133
3	PBN-82-01A,B,&C		PBN-85-02A	35	SPN-89-02A,B,&C
4	LOM-89-01	22	PBM-85-03		SPN-91-02D
5	LON-89-03A&B	23	PBN-89-01B,C,&D	36	SPN-89-03B&C
6	LON-89-02A&B		PBN-85-01A		SPN-91-03D
7	PBN-82-02AB,&C	24	PBM-85-02		S1147
8	PBN-89-10A,B,C,&D	25	PBN-89-03B&C	37	SPN-89-04B&C
9	PBM-82-02		PBN-85-03A		S1148, SPN-91-04D
10	S1144	26	PBM-89-05	38	S1102, S1103, S1149
11	PBM-82-01	27	PBM-85-04	39	S1152A&B
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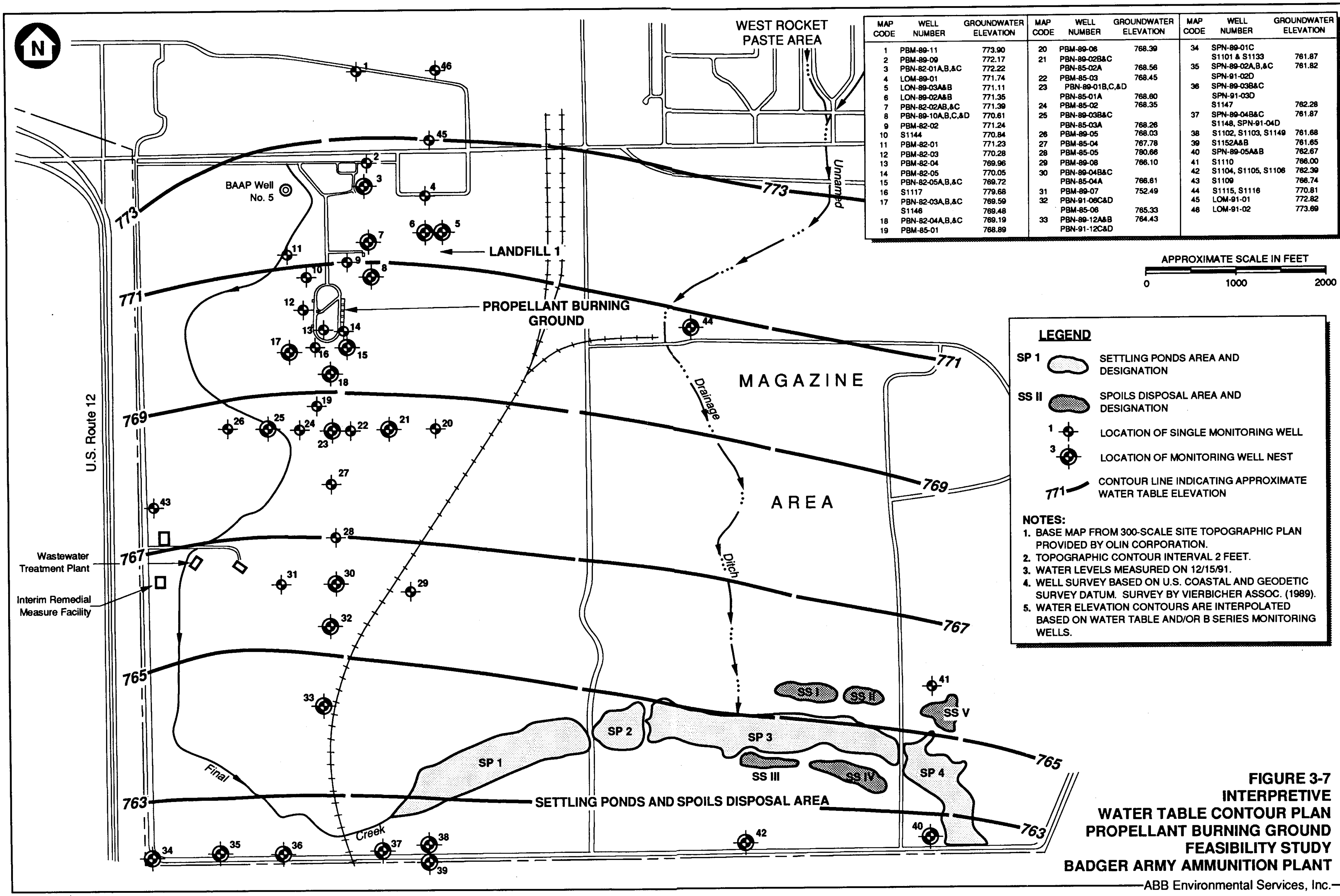
14	PBM-82-05	30	PBN-89-04B&C	42	S1104, S1105, S1106
15	PBN-82-05A,B,&C		PBN-85-04A	43	S1109
16	S1117	31	PBM-89-07	44	S1115, S1116
17	PBN-82-03A,B,&C	32	PBN-91-06C&D	45	LOM-91-01
	S1146		PBM-85-06	46	LOM-91-02
18	PBN-82-04A,B,&C	33	PBN-89-12A&B		
19	PBM-85-01		PBN-91-12C&D		

FIGURE 3-6
MONITORING WELL LOCATIONS
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9211045D de



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5	LON-89-03A&B	771.11
6	LON-89-02A&B	771.35
7	PBN-82-02AB,&C	771.39
8	PBN-89-10A,B,C,&D	770.61
9	PBM-82-02	771.24
10	S1144	770.84
11	PBM-82-01	771.23
12	PBM-82-03	770.28
13	PBM-82-04	769.96
14	PBM-82-05	770.05
15	PBN-82-05A,B,&C	769.72
16	S1117	779.68
17	PBN-82-03A,B,&C	769.59
	S1146	769.48
18	PBN-82-04A,B,&C	769.19
19	PBM-85-01	768.89

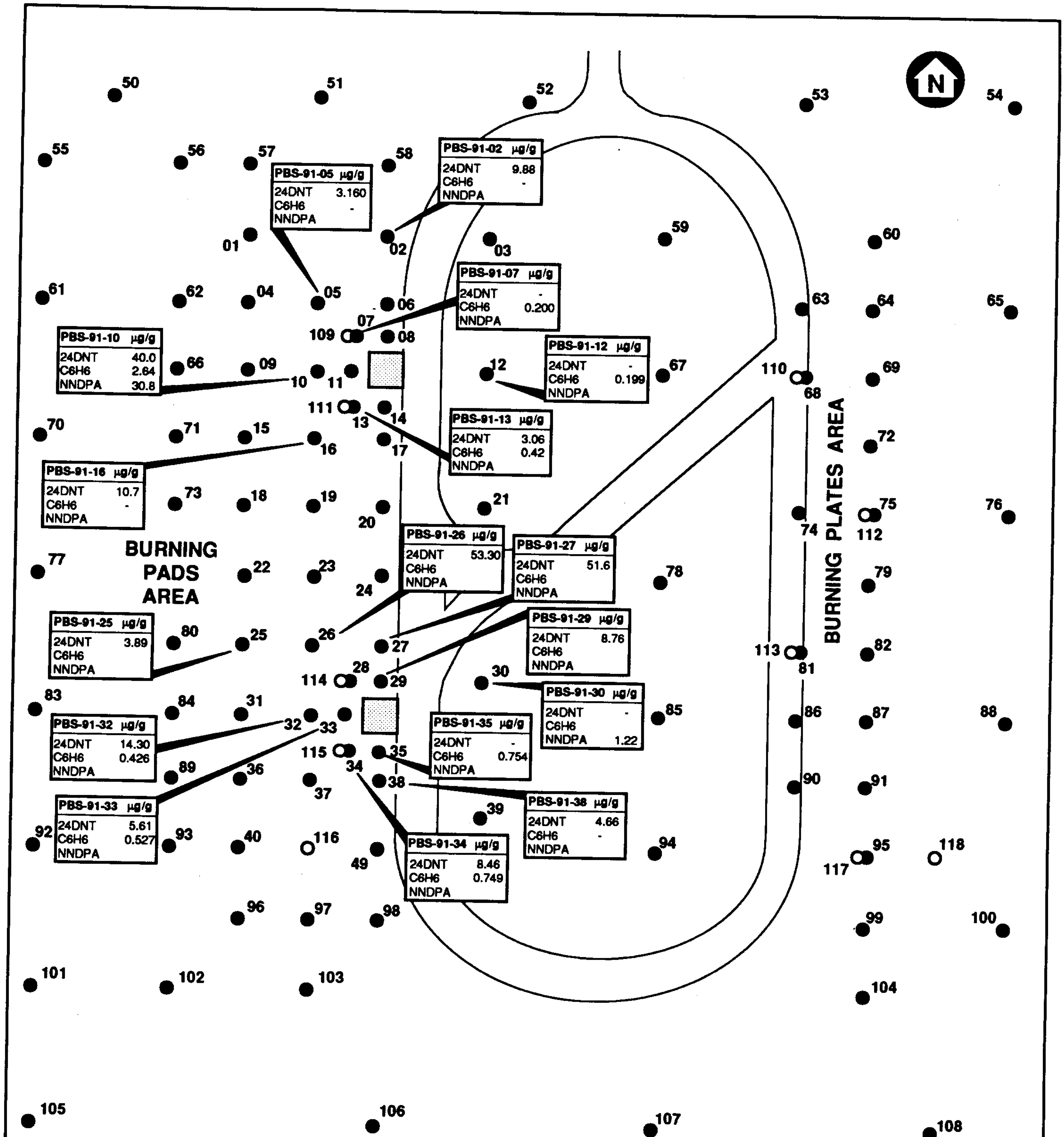
MAP CODE	WELL NUMBER	GROUNDWATER ELEVATION
20	PBM-89-06	768.39
21	PBN-89-02B&C	
	PBN-85-02A	768.56
22	PBM-85-03	768.45
23	PBN-89-01B,C,&D	
	PBN-85-01A	768.60
24	PBM-85-02	768.35
25	PBN-89-03B&C	
	PBN-85-03A	768.26
26	PBM-89-05	768.03
27	PBM-85-04	767.78
28	PBM-85-05	780.66
29	PBM-89-08	766.10
30	PBN-89-04B&C	
	PBN-85-04A	766.61
31	PBM-89-07	752.49
32	PBN-91-06C&D	
	PBM-85-06	765.33
33	PBN-89-12A&B	764.43
	PBN-91-12C&D	

MAP CODE	WELL NUMBER	GROUNDWATER ELEVATION
34	SPN-89-01C	
	S1101 & S1133	761.87
35	SPN-89-02A,B,&C	761.82
	SPN-91-02D	
36	SPN-89-03B&C	
	SPN-91-03D	
	S1147	762.28
37	SPN-89-04B&C	761.87
	S1148, SPN-91-04D	
38	S1102, S1103, S1149	761.68
39	S1152A&B	761.65
40	SPN-89-05A&B	762.67
41	S1110	766.00
42	S1104, S1105, S1106	762.39
43	S1109	766.74
44	S1115, S1116	770.81
45	LOM-91-01	772.82
46	LOM-91-02	773.69

FIGURE 3-7
INTERPRETIVE
WATER TABLE CONTOUR PLAN
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9211045D d m



LEGEND

01 ● SURFACE SOIL SAMPLE LOCATION (PBS-91-01)

109 ○ SUBSURFACE SOIL SAMPLE LOCATION (PBS-91-109)

▒ APPROXIMATE SIZE OF CONCRETE BURNING PADS

- = NON-DETECT

BLANK = NO ANALYSIS PERFORMED

SCALE IN FEET

0 100 200

NOTES:

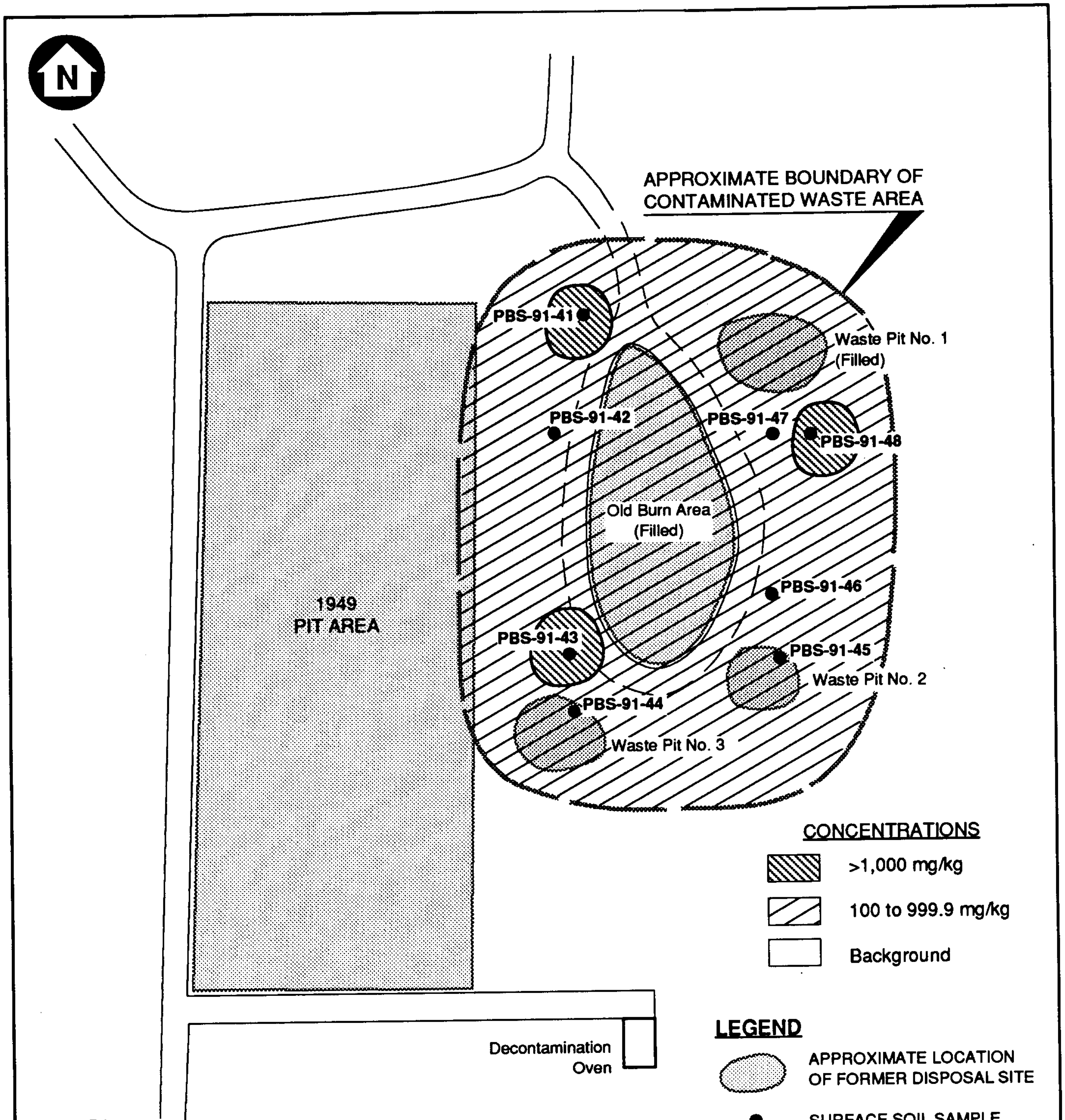
1. SEE REMEDIAL INVESTIGATION REPORT FOR CHEMICAL DATA SUMMARY (ABB-ES, 1993a).
2. SAMPLE LOCATIONS 41-48 ARE LOCATED OFF THE GRID IN THE CONTAMINATED WASTE AREA.

SOURCE: MODIFIED FROM FIGURE 4-12 OF TSAI ET AL., 1988.

FIGURE 3-8
DISTRIBUTION OF 24DNT, C6H6, AND NNDPA IN SURFACE SOILS AT THE RACETRACK PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9211047D 345



NOTES:
1. PB ISOCONCENTRATION LINES ARE DASHED WHERE INTERPRETIVE.
2. SEE REMEDIAL INVESTIGATION REPORT FOR CHEMICAL DATA SUMMARY (ABB-ES, 1993a).

APPROXIMATE SCALE IN FEET

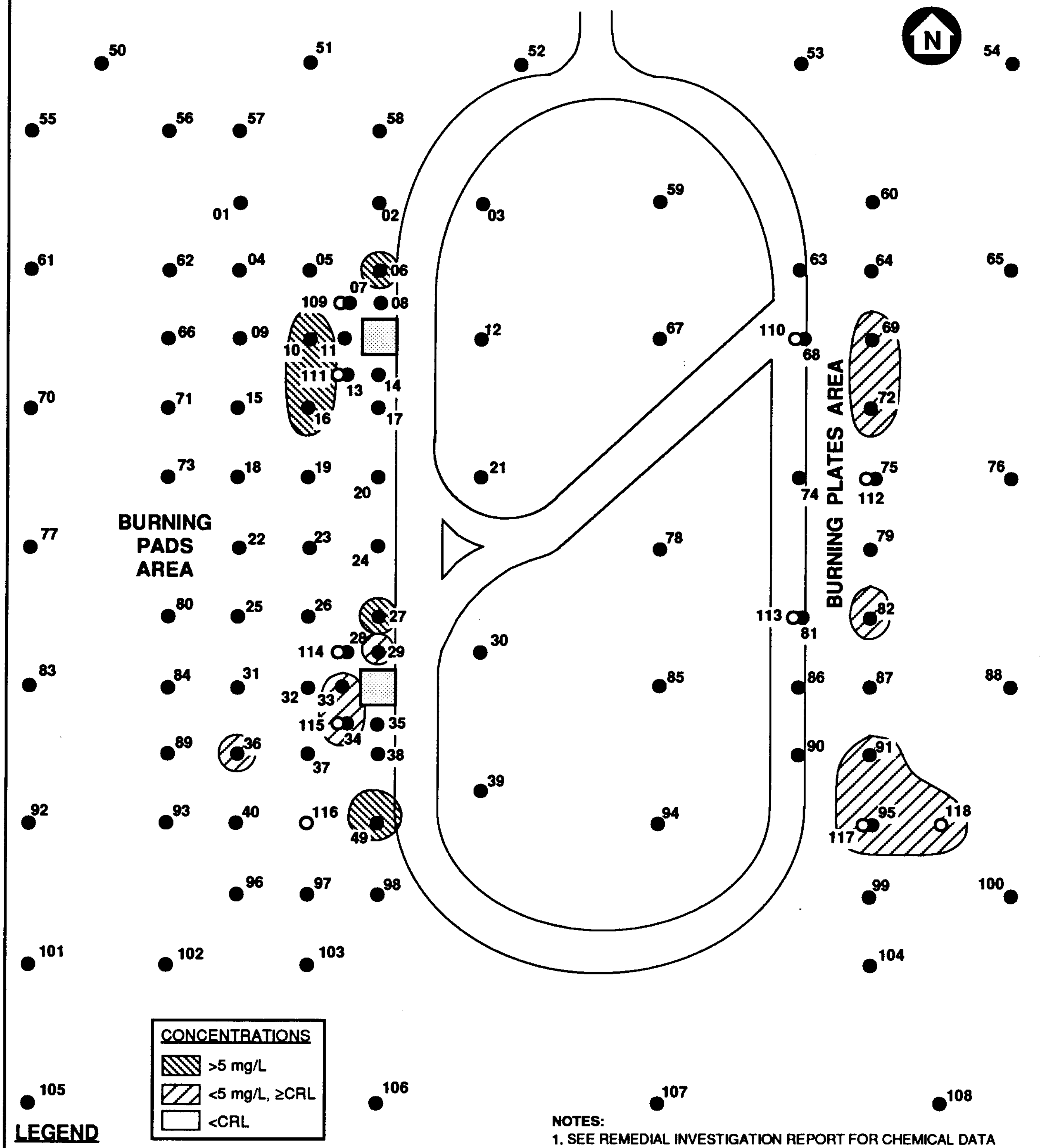
0 150 300

Source: Modified from Tsai, et.al., 1988.

FIGURE 3-10
INTERPRETIVE PB DISTRIBUTION IN SURFACE SOILS AT THE CONTAMINATED WASTE AREA PROPELLANT BURNING GROUND FEASIBILITY STUDY BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9211049D 2



LEGEND

01 ● SURFACE SOIL SAMPLE LOCATION (PBS-91-01)

109 ○ SUBSURFACE SOIL SAMPLE LOCATION (PBS-91-109)

APPROXIMATE SIZE OF CONCRETE BURNING PADS

CRL - CERTIFIED REPORTING LIMIT

SCALE IN FEET

0 100 200

NOTES:
1. SEE REMEDIAL INVESTIGATION REPORT FOR CHEMICAL DATA SUMMARY (ABB-ES, 1993a).
2. SAMPLE LOCATIONS 41-48 ARE LOCATED OFF THE GRID IN THE CONTAMINATED WASTE AREA.

SOURCE: MODIFIED FROM FIGURE 4-12 OF TSAI ET AL., 1988.

FIGURE 3-11
INTERPRETIVE TCLP PB DISTRIBUTION IN SURFACE SOILS AT THE RACETRACK AREA
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9211047D1 34 6

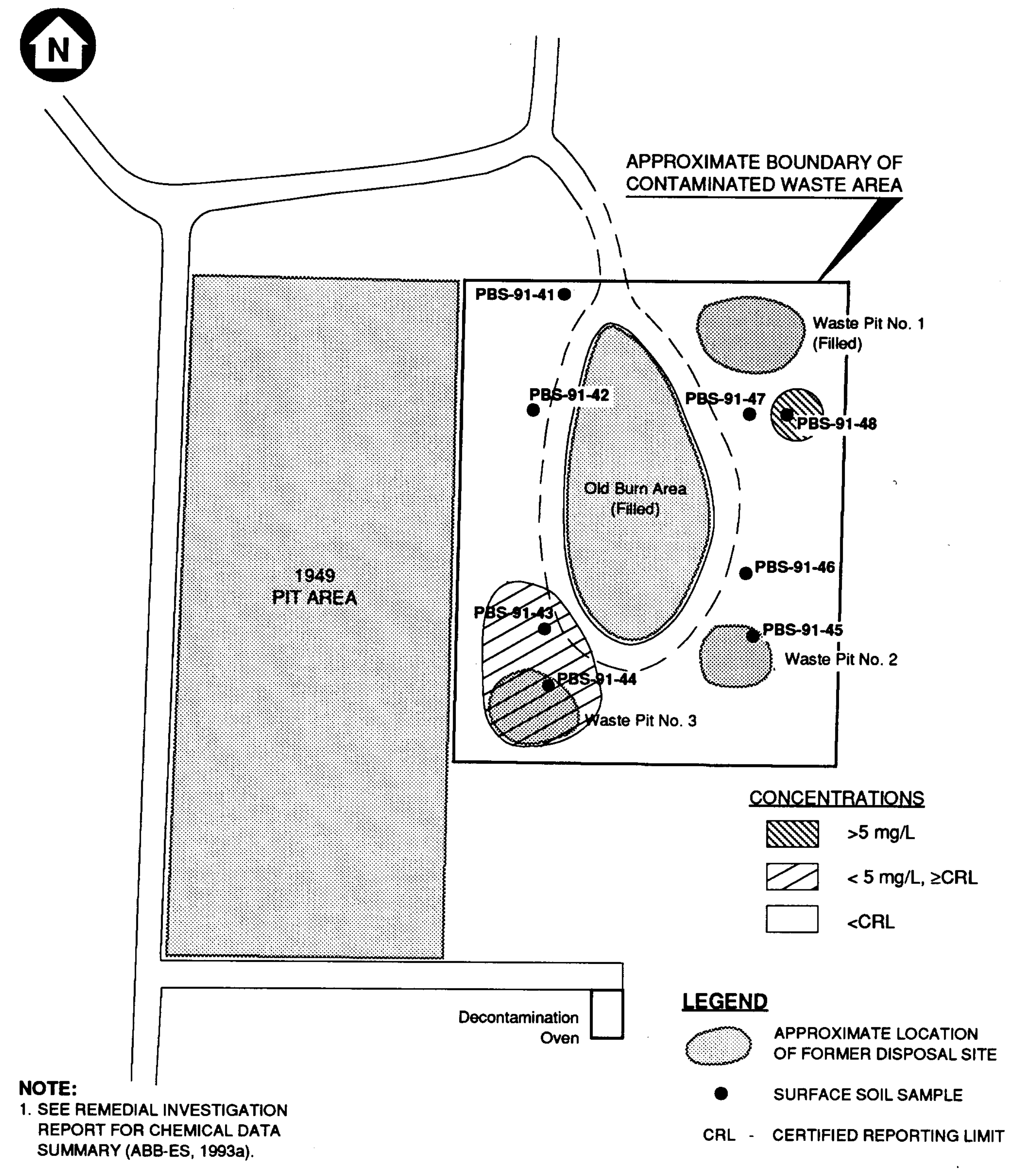


FIGURE 3-12
INTERPRETIVE TCLP PB DISTRIBUTION IN SURFACE SOILS
IN THE CONTAMINATED WASTE AREA
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

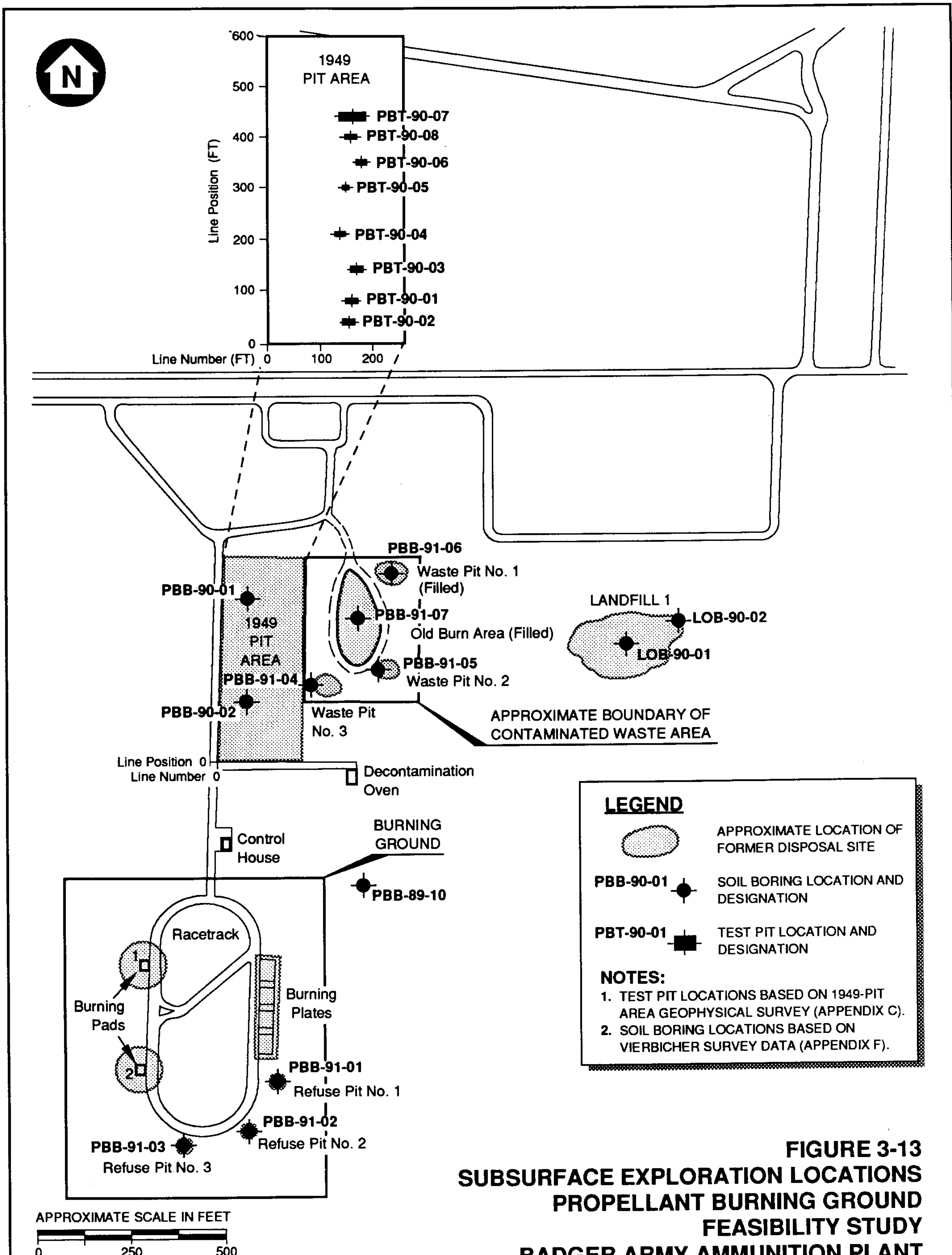
APPROXIMATE SCALE IN FEET

0 150 300

Source: Modified from Tsai, et.al., 1988.

ABB Environmental Services, Inc.

9211049D 4

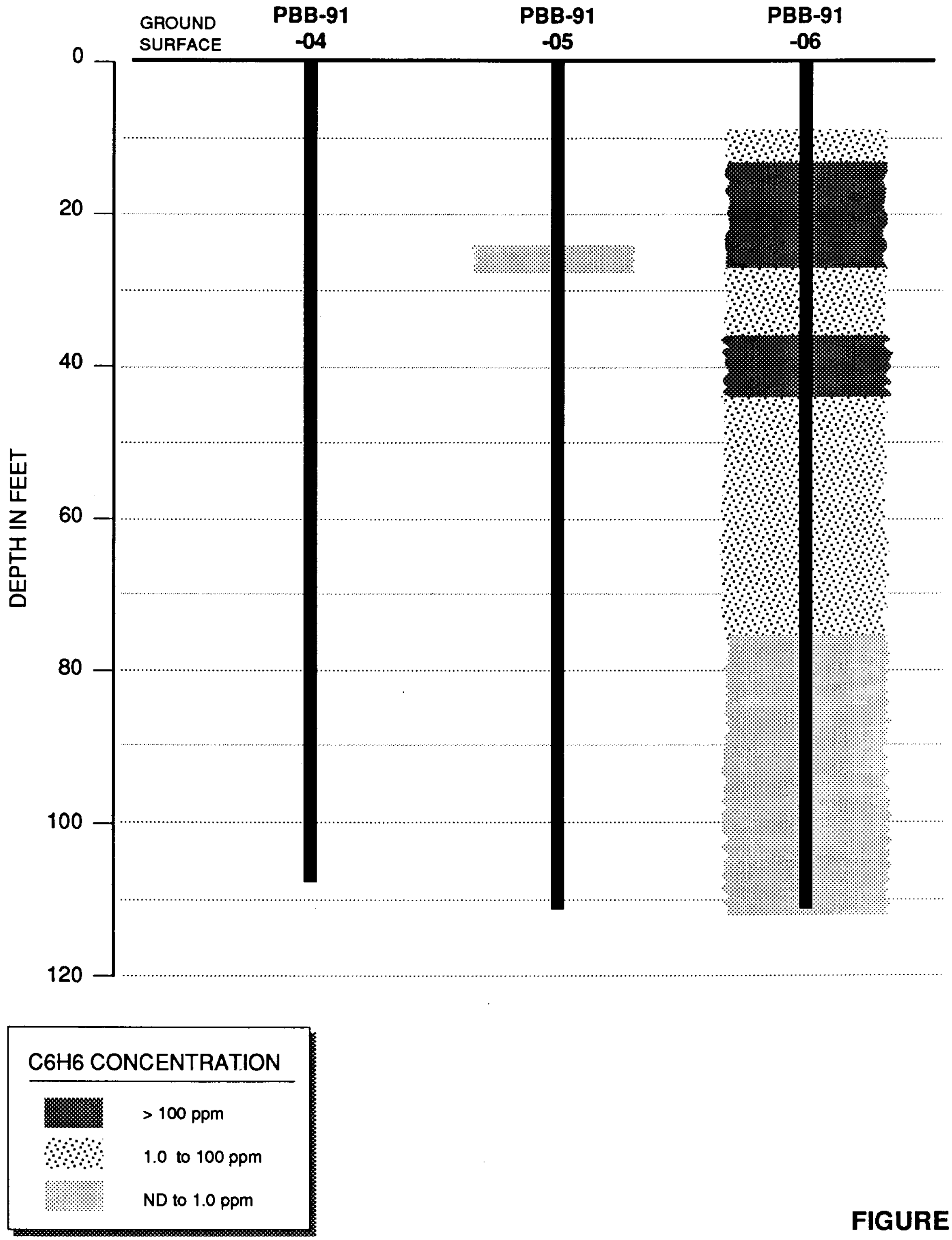


Source: Modified from Tsai, et.al., 1988.

FIGURE 3-13
SUBSURFACE EXPLORATION LOCATIONS
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9305063D1 3

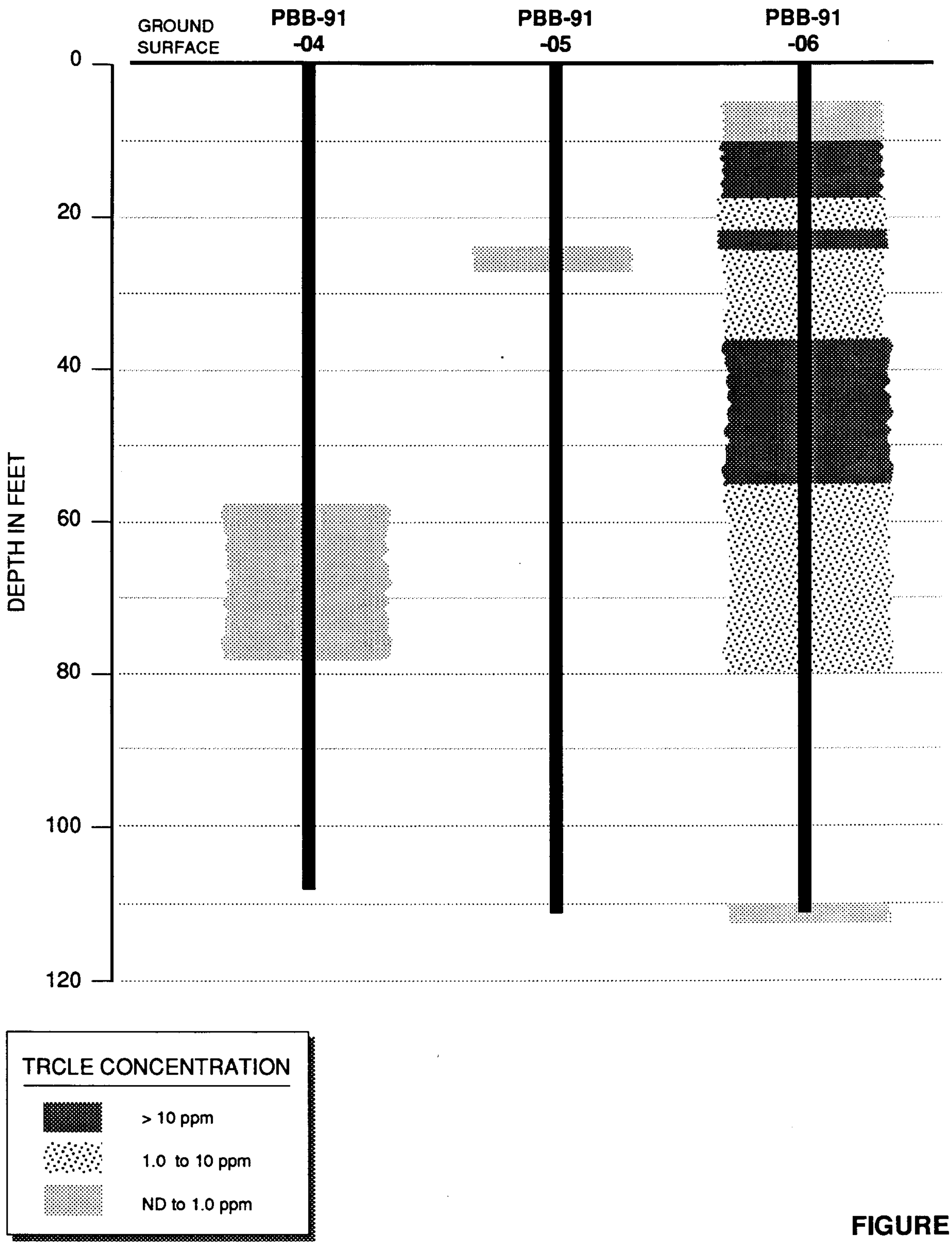


NOTE:
1. SEE REMEDIAL INVESTIGATION REPORT FOR CHEMICAL DATA SUMMARY (ABB-ES, 1993a).

FIGURE 3-14
INTERPRETIVE C6H6 CONCENTRATIONS IN SUBSURFACE SOILS
PROPELLANT BURNING GROUND WASTE PITS
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

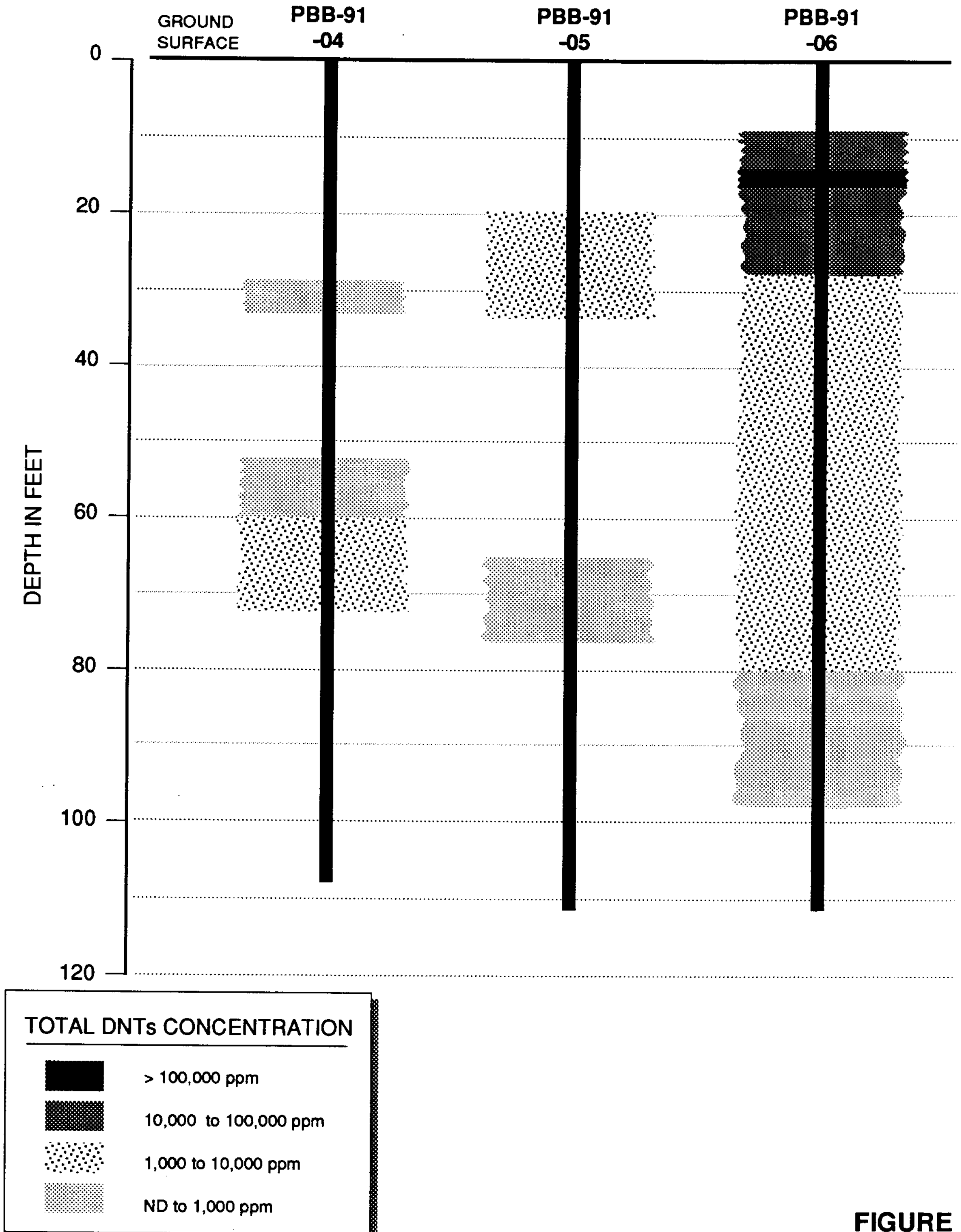
9211050D1



NOTE:
1. SEE REMEDIAL INVESTIGATION REPORT FOR CHEMICAL DATA SUMMARY (ABB-ES, 1993a).

FIGURE 3-15
INTERPRETIVE TRCLE CONCENTRATIONS IN SUBSURFACE SOILS
PROPELLANT BURNING GROUND WASTE PITS
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

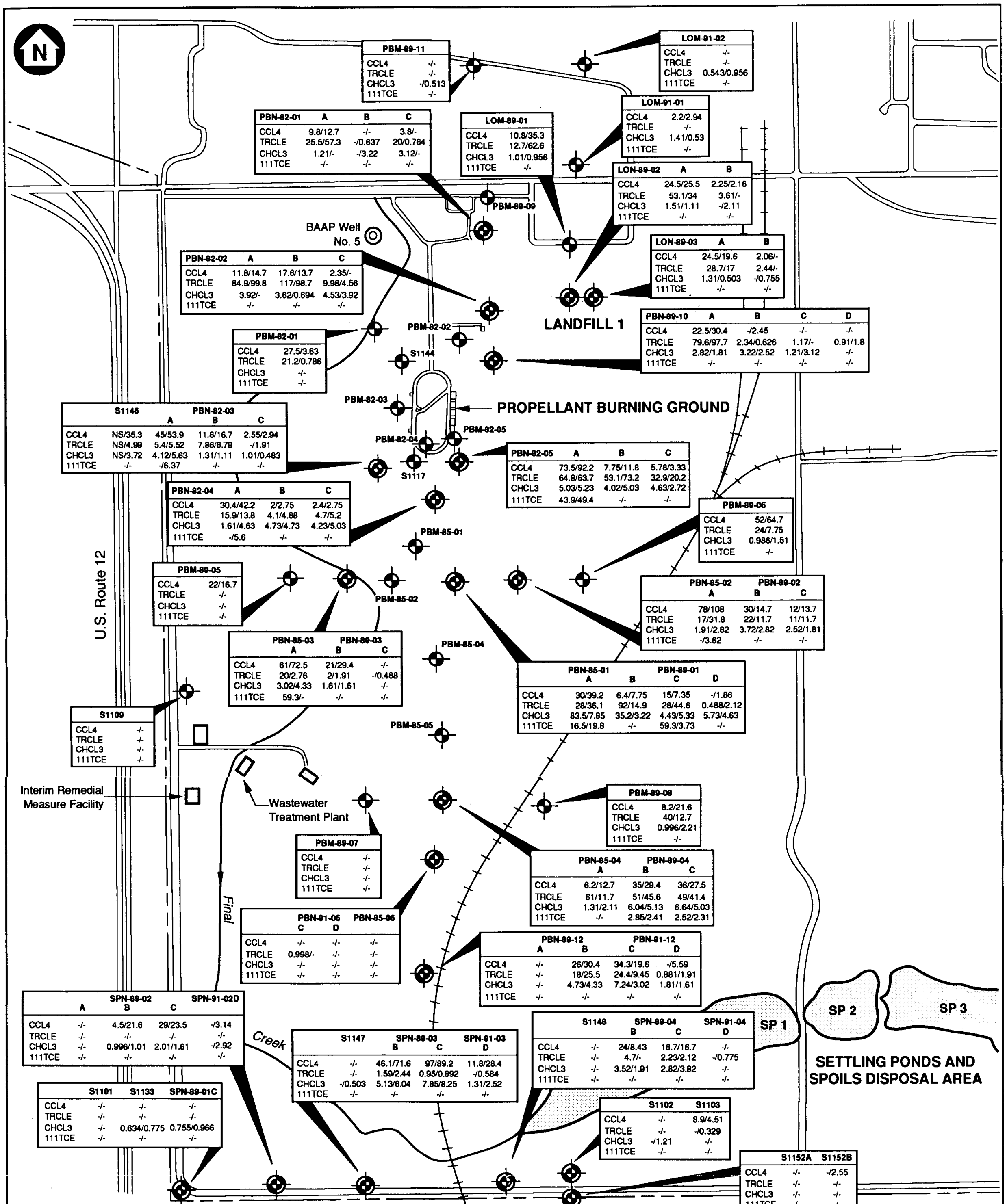
ABB Environmental Services, Inc.



NOTE:

1. SEE REMEDIAL INVESTIGATION REPORT FOR CHEMICAL DATA SUMMARY (ABB-ES, 1993a).

FIGURE 3-16
INTERPRETIVE TOTAL DNT CONCENTRATIONS IN SUBSURFACE SOILS
PROPELLANT BURNING GROUND WASTE PITS
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT



LEGEND

SP 1 SPOILS DISPOSAL AREA AND DESIGNATION

FINAL CREEK

RAILROAD TRACK

LOCATION OF SINGLE MONITORING WELL

LOCATION OF MONITORING WELL NEST

LON-89-02 A B — SAMPLE LOCATION

CCL4 -/- 2.7/3.2

- COMPOUND CONCENTRATION IN SAMPLE (μg/L) FROM ROUND ONE OF SAMPLING (NOV/DEC 1991)
- COMPOUND CONCENTRATION IN SAMPLE (μg/L) FROM ROUND TWO OF SAMPLING (APR/MAY 1992)
- COMPOUND OF CONCERN
- \- = LESS THAN CERTIFIED REPORTING LIMIT (CRL)

APPROXIMATE SCALE IN FEET

0 1000 2000

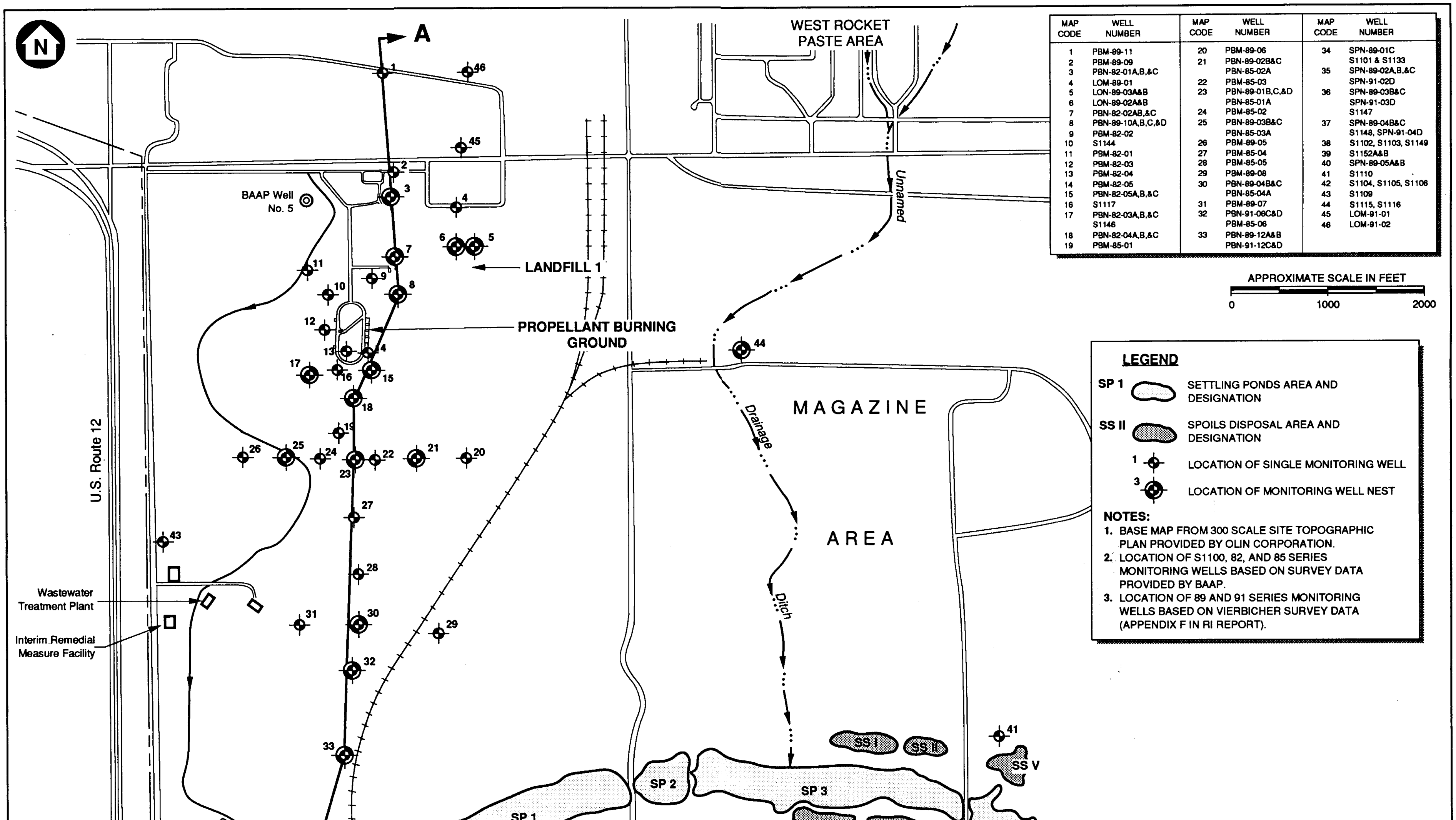
NOTES:

1. GROUNDWATER DATA PRESENTED IS PRIMARILY FROM MONITORING WELL NESTS TO BETTER DETERMINE VERTICAL DISTRIBUTION OF CHEMICAL CONCENTRATIONS.
2. CCL4 = CARBON TETRACHLORIDE
   TRCLE = TRICHLOROETHENE
   CHCL3 = CHLOROFORM
   111TCE = 1,1,1-TRICHLOROETHANE
3. ALL ANALYTICAL RESULTS REPORTED IN MICROGRAMS PER LITER (μg/L).
4. BASE MAP PREPARED FROM 300 SCALE TOPOGRAPHIC PLAN PROVIDED BY OLIN CORPORATION.

FIGURE 3-17
SUMMARY OF SELECTED VOC GROUNDWATER DATA
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9211051D

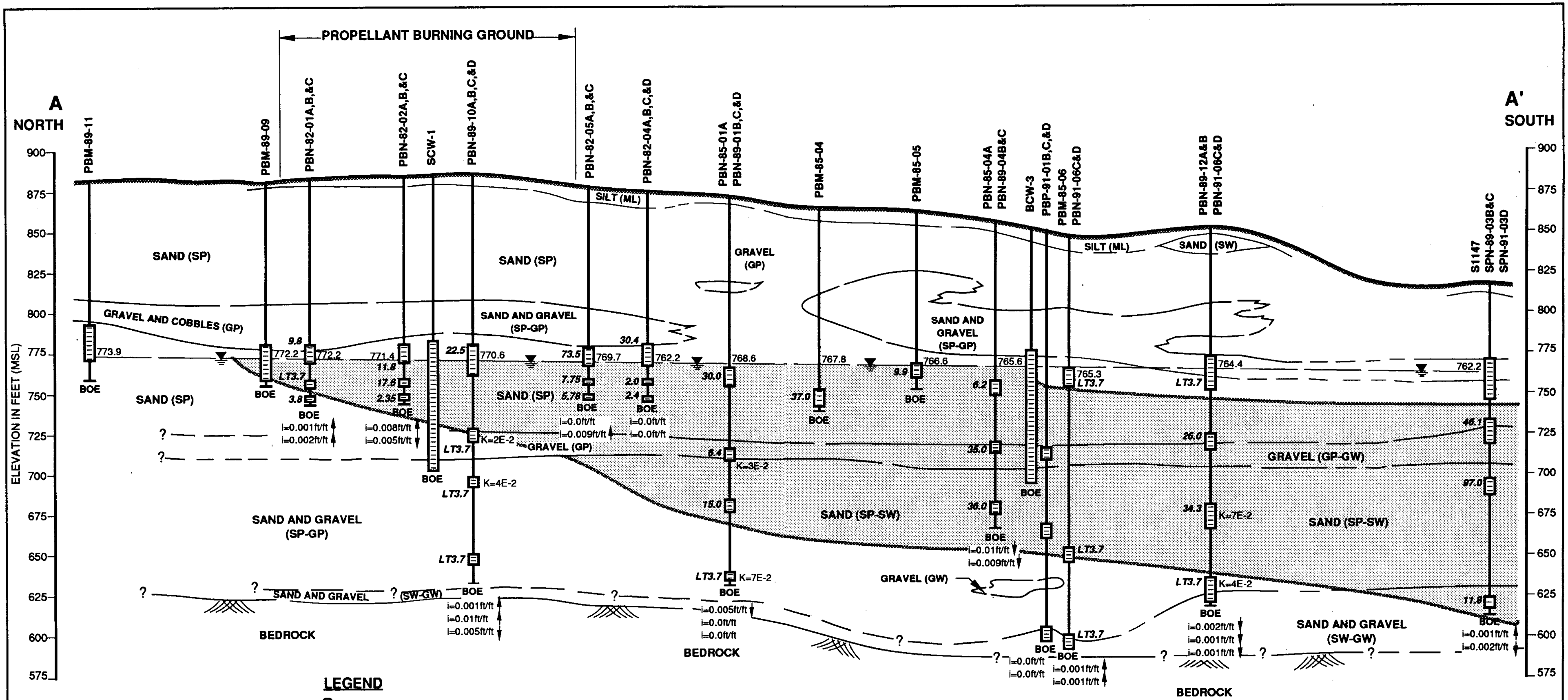


MAP CODE	WELL NUMBER	MAP CODE	WELL NUMBER	MAP CODE	WELL NUMBER
1	PBM-89-11	20	PBM-89-06	34	SPN-89-01C
2	PBM-89-09	21	PBN-89-02B&C		S1101 & S1133
3	PBN-82-01A,B,&C		PBN-85-02A	35	SPN-89-02A,B,&C
4	LOM-89-01	22	PBM-85-03		SPN-91-02D
5	LON-89-03A&B	23	PBN-89-01B,C,&D	36	SPN-89-03B&C
6	LON-89-02A&B		PBN-85-01A		SPN-91-03D
7	PBN-82-02AB,&C	24	PBM-85-02		S1147
8	PBN-89-10A,B,C,&D	25	PBN-89-03B&C	37	SPN-89-04B&C
9	PBM-82-02		PBN-85-03A		S1148, SPN-91-04D
10	S1144	26	PBM-89-05	38	S1102, S1103, S1149
11	PBM-82-01	27	PBM-85-04	39	S1152A&B
12	PBM-82-03	28	PBM-85-05	40	SPN-89-05A&B
13	PBM-82-04	29	PBM-89-08	41	S1110
14	PBM-82-05	30	PBN-89-04B&C	42	S1104, S1105, S1106
15	PBN-82-05A,B,&C		PBN-85-04A	43	S1109
16	S1117	31	PBM-89-07	44	S1115, S1116
17	PBN-82-03A,B,&C	32	PBN-91-06C&D	45	LOM-91-01
	S1146		PBM-85-06	46	LOM-91-02
18	PBN-82-04A,B,&C	33	PBN-89-12A&B		
19	PBM-85-01		PBN-91-12C&D		

FIGURE 3-18
ORIENTATION OF CONTAMINANT PLUME CROSS SECTION A-A'
PROPELLANT BURNING GROUND FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9211045D d kl



LEGEND

PBN-89-10 A,B,C,&D	WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,&D)
	GROUND SURFACE
SAND (SP)	SOILS DESCRIPTION AND USCS CLASSIFICATION
773.9	WATER TABLE ELEVATION
22.5	CCL4 CONCENTRATION IN ug/L
	SCREENED INTERVAL
K=5E-3	IN-FIELD PERMEABILITY TEST RESULTS IN cm/sec
BOE	BOTTOM OF EXPLORATION
i=0.001ft/ft	GROUNDWATER VERTICAL GRADIENT (ARROW INDICATES DIRECTION OF VERTICAL GRADIENT)
	ESTIMATED EXTENT OF CCL4 PLUME

SCALE IN FEET

0 400 800

VERTICAL EXAGGERATON 1:10

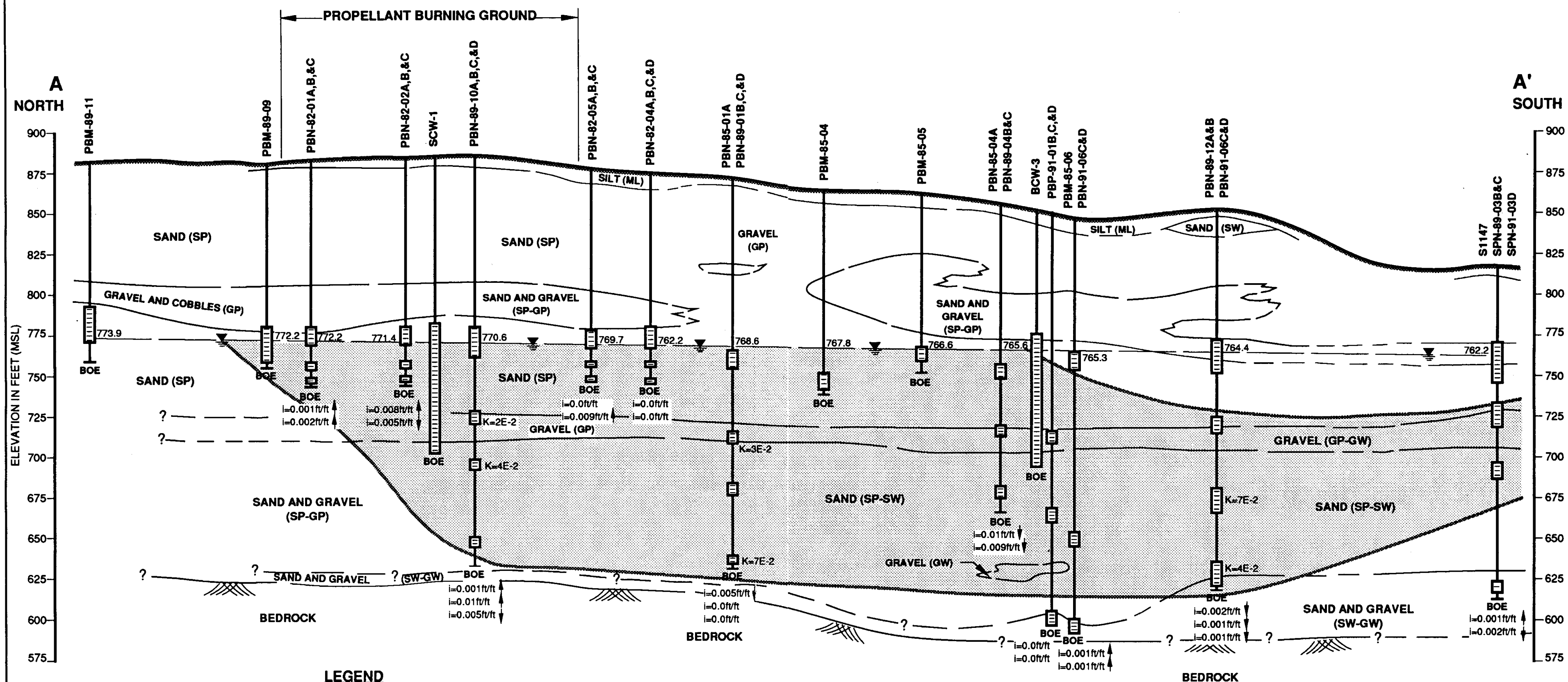
NOTES:

1. SEE FIGURE 3-2 FOR LOCATION AND ORIENTATION OF PROFILE.
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA. ACTUAL CONDITIONS BETWEEN EXPLORATIONS MAY VARY FROM THOSE SHOWN.
3. ON MULTIPLE WELL NESTS, GRADIENTS ARE LISTED IN ORDER OF SHALLOW TO DEEP WELLS; i.e., A TO B, B TO C AND C TO D.
4. WATER LEVELS MEASURED IN WATER TABLE WELLS ON 12/15/91 ARE LISTED.
5. BEDROCK SURFACE ELEVATION ESTIMATED FROM PBB-89-10 AND PRODUCTION WELL NO. 5.
6. BEDROCK SURFACE ELEVATION ESTIMATED FROM PBN-89-12D (LOCATED ADJACENT TO PBN-89-10), SPN-91-04D (LOCATED APPROXIMATELY 1200 FEET EAST OF SPN-91-03D), AND PRODUCTION WELL NO. 5 (LOCATED APPROXIMATELY 1000 FEET NORTH OF PBN-89-10).
7. PBP-91-01B,C,&D IS USED ONLY FOR GEOLOGIC INFORMATION AND AQUIFER ANALYSIS. IT IS NOT A MONITORING WELL CLUSTER.

FIGURE 3-19
CONTAMINANT PLUME CROSS SECTION - CCL4
PROPELLANT BURNING GROUND FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9305003D 67



LEGEND

PBN-89-10 A,B,C,&D	WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B,C,&D)
	GROUND SURFACE
SAND (SP)	SOILS DESCRIPTION AND USCS CLASSIFICATION
773.9	WATER TABLE ELEVATION
	SCREENED INTERVAL
K=5E-3	IN-FIELD PERMEABILITY TEST RESULTS IN cm/sec
BOE	BOTTOM OF EXPLORATION
i=0.001ft/ft	GROUNDWATER VERTICAL GRADIENT (ARROW INDICATES DIRECTION OF VERTICAL GRADIENT)
	ESTIMATED EXTENT OF TRCLE PLUME

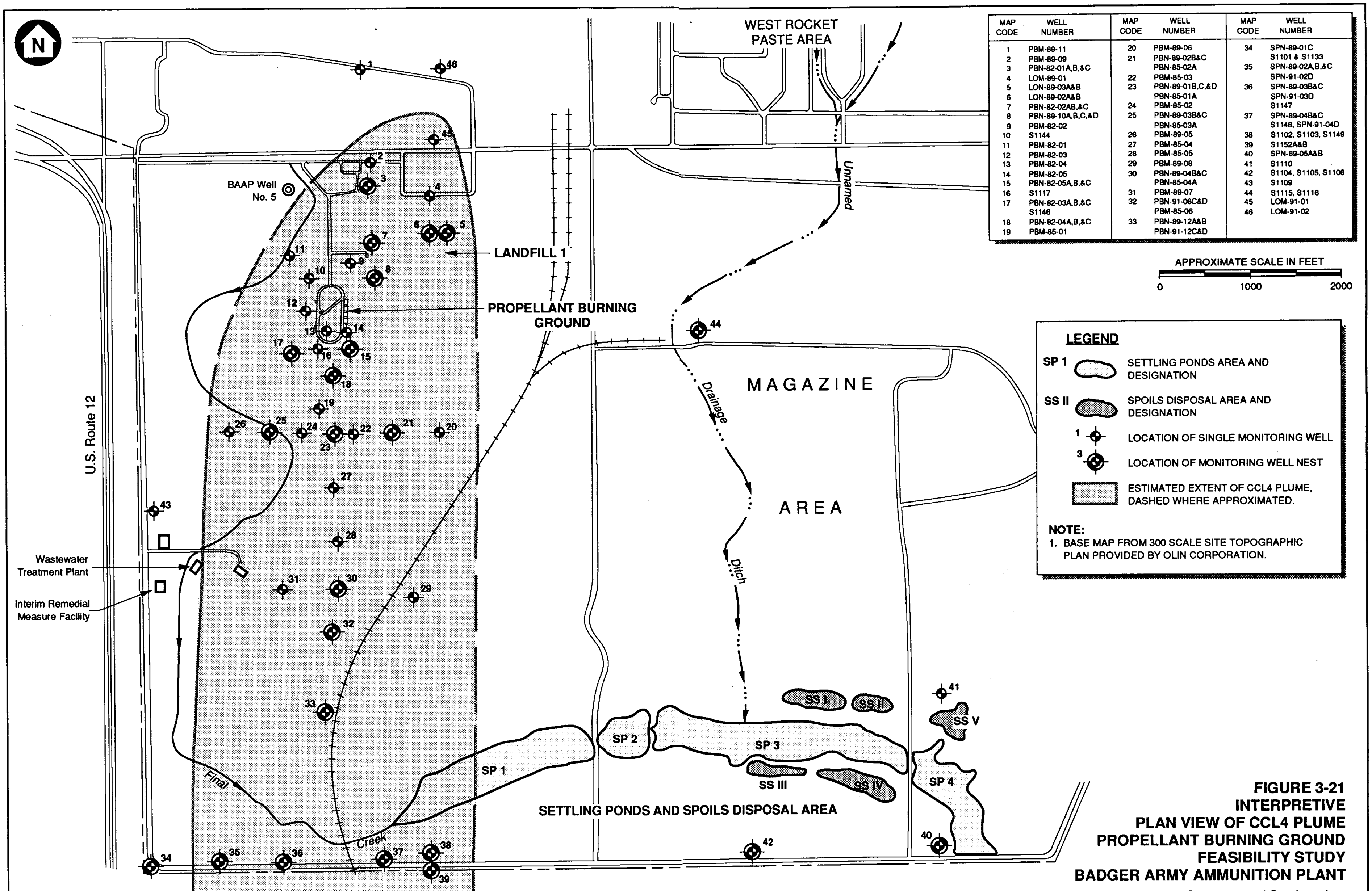
SCALE IN FEET
0 400 800
VERTICAL EXAGGERATON 1:10

NOTES:
1. SEE FIGURE 3-2 FOR LOCATION AND ORIENTATION OF PROFILE.
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA. ACTUAL CONDITIONS BETWEEN EXPLORATIONS MAY VARY FROM THOSE SHOWN.
3. ON MULTIPLE WELL NESTS, GRADIENTS ARE LISTED IN ORDER OF SHALLOW TO DEEP WELLS; i.e., A TO B, B TO C AND C TO D.
4. WATER LEVELS MEASURED IN WATER TABLE WELLS ON 12/15/91 ARE LISTED.
5. BEDROCK SURFACE ELEVATION ESTIMATED FROM PBB-89-10 AND PRODUCTION WELL NO. 5.
6. BEDROCK SURFACE ELEVATION ESTIMATED FROM PBN-89-12D (LOCATED ADJACENT TO PBN-89-10), SPN-91-04D (LOCATED APPROXIMATELY 1200 FEET EAST OF SPN-91-03D), AND PRODUCTION WELL NO. 5 (LOCATED APPROXIMATELY 1000 FEET NORTH OF PBN-89-10).
7. PBP-91-01B,C,&D IS USED ONLY FOR GEOLOGIC INFORMATION AND AQUIFER ANALYSIS. IT IS NOT A MONITORING WELL CLUSTER.

FIGURE 3-20
CONTAMINANT PLUME
CROSS SECTION - TRCLE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

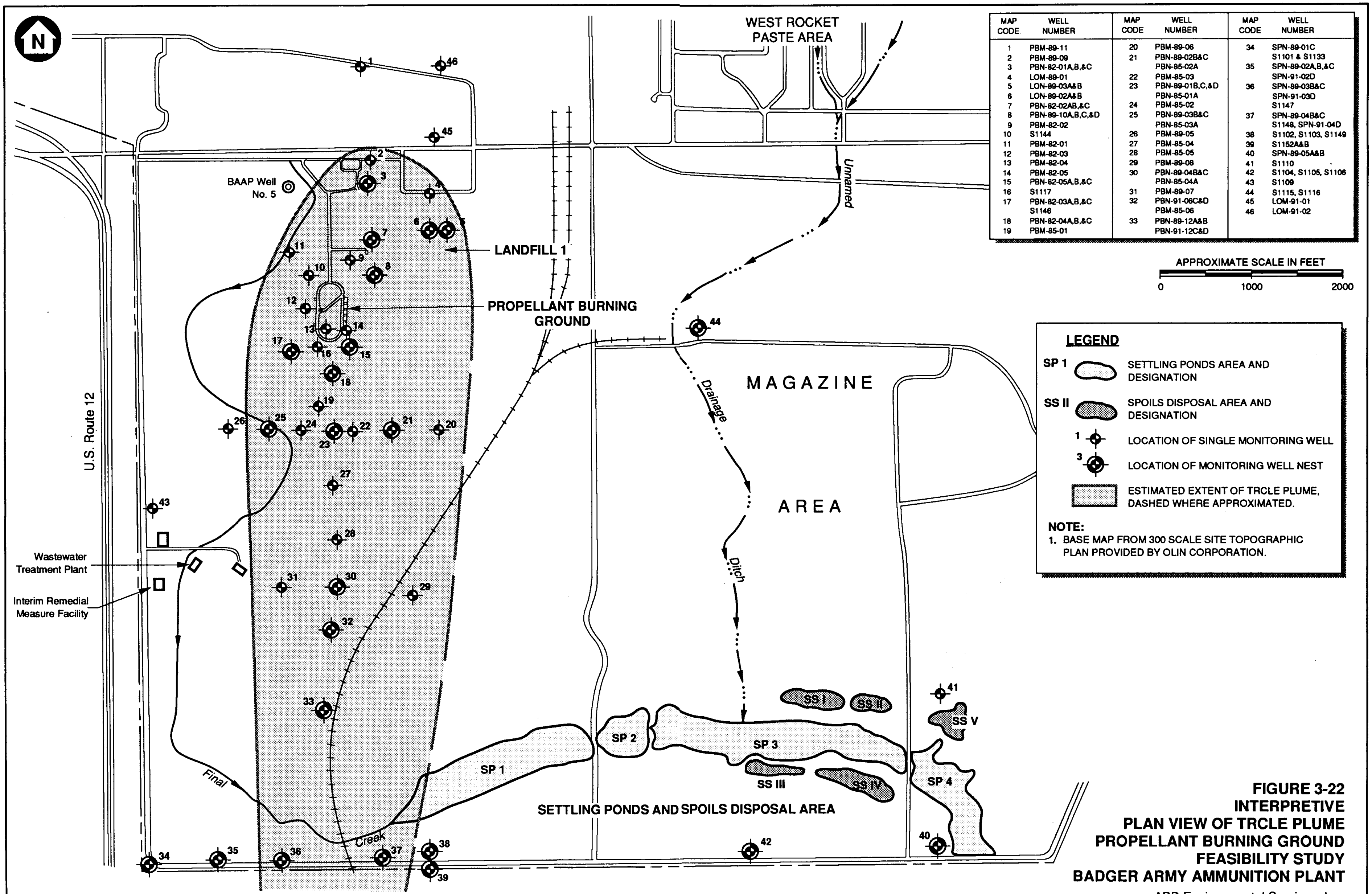
9305003D 89



MAP CODE	WELL NUMBER	MAP CODE	WELL NUMBER	MAP CODE	WELL NUMBER
1	PBM-89-11	20	PBM-89-06	34	SPN-89-01C
2	PBM-89-09	21	PBN-89-02B&C		S1101 & S1133
3	PBN-82-01A,B,&C		PBN-85-02A	35	SPN-89-02A,B,&C
4	LOM-89-01	22	PBM-85-03		SPN-91-02D
5	LON-89-03A&B	23	PBN-89-01B,C,&D	36	SPN-89-03B&C
6	LON-89-02A&B		PBN-85-01A		SPN-91-03D
7	PBN-82-02AB,&C	24	PBM-85-02		S1147
8	PBN-89-10A,B,C,&D	25	PBN-89-03B&C	37	SPN-89-04B&C
9	PBM-82-02		PBN-85-03A		S1148, SPN-91-04D
10	S1144	26	PBM-89-05	38	S1102, S1103, S1149
11	PBM-82-01	27	PBM-85-04	39	S1152A&B
12	PBM-82-03	28	PBM-85-05	40	SPN-89-05A&B
13	PBM-82-04	29	PBM-89-08	41	S1110
14	PBM-82-05	30	PBN-89-04B&C	42	S1104, S1105, S1106
15	PBN-82-05A,B,&C		PBN-85-04A	43	S1109
16	S1117	31	PBM-89-07	44	S1115, S1116
17	PBN-82-03A,B,&C	32	PBN-91-06C&D	45	LOM-91-01
	S1146		PBM-85-06	46	LOM-91-02
18	PBN-82-04A,B,&C	33	PBN-89-12A&B		
19	PBM-85-01		PBN-91-12C&D		

FIGURE 3-21
INTERPRETIVE
PLAN VIEW OF CCL4 PLUME
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

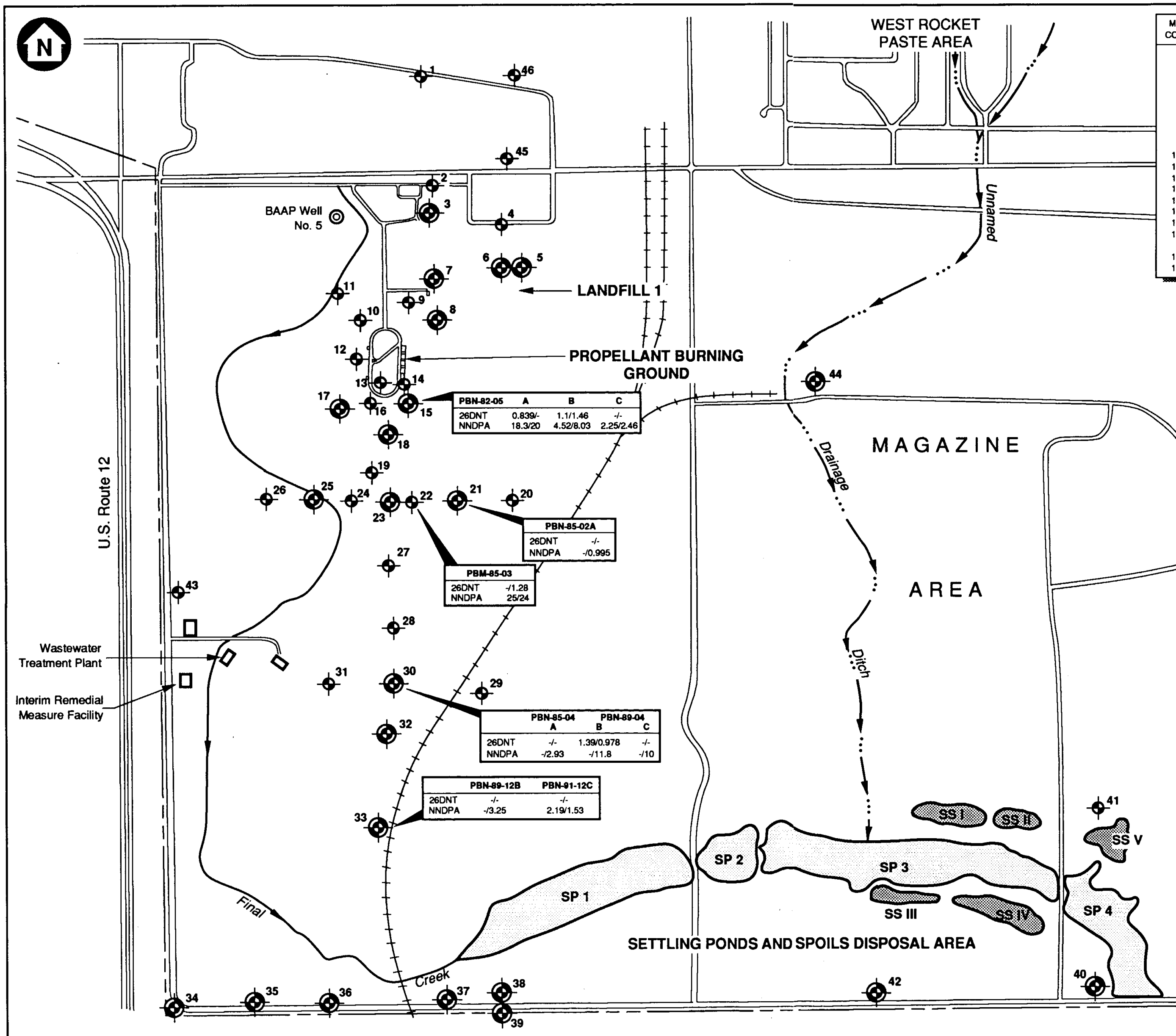


MAP CODE	WELL NUMBER
1	PBM-89-11
2	PBM-89-09
3	PBN-82-01A,B,&C
4	LOM-89-01
5	LON-89-03A&B
6	LON-89-02A&B
7	PBN-82-02AB,&C
8	PBN-89-10A,B,C,&D
9	PBM-82-02
10	S1144
11	PBM-82-01
12	PBM-82-03
13	PBM-82-04
14	PBM-82-05
15	PBN-82-05A,B,&C
16	S1117
17	PBN-82-03A,B,&C
	S1146
18	PBN-82-04A,B,&C
19	PBM-85-01

MAP CODE	WELL NUMBER
20	PBM-89-06
21	PBN-89-02B&C
	PBN-85-02A
22	PBM-85-03
23	PBN-89-01B,C,&D
	PBN-85-01A
24	PBM-85-02
25	PBN-89-03B&C
	PBN-85-03A
26	PBM-89-05
27	PBM-85-04
28	PBM-85-05
29	PBM-89-08
30	PBN-89-04B&C
	PBN-85-04A
31	PBM-89-07
32	PBN-91-06C&D
	PBM-85-06
33	PBN-89-12A&B
	PBN-91-12C&D

MAP CODE	WELL NUMBER
34	SPN-89-01C
	S1101 & S1133
35	SPN-89-02A,B,&C
	SPN-91-02D
36	SPN-89-03B&C
	SPN-91-03D
	S1147
37	SPN-89-04B&C
	S1148, SPN-91-04D
38	S1102, S1103, S1149
39	S1152A&B
40	SPN-89-05A&B
41	S1110
42	S1104, S1105, S1106
43	S1109
44	S1115, S1116
45	LOM-91-01
46	LOM-91-02

FIGURE 3-22
INTERPRETIVE
PLAN VIEW OF TRCLE PLUME
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT



MAP CODE	WELL NUMBER	MAP CODE	WELL NUMBER	MAP CODE	WELL NUMBER
1	PBM-89-11	20	PBM-89-06	34	SPN-89-01C
2	PBM-89-09	21	PBN-89-02B&C		S1101 & S1133
3	PBN-82-01A,B,&C		PBN-85-02A	35	SPN-89-02A,B,&C
4	LOM-89-01	22	PBM-85-03		SPN-91-02D
5	LON-89-03A&B	23	PBN-89-01B,C,&D	36	SPN-89-03B&C
6	LON-89-02A&B		PBN-85-01A		SPN-91-03D
7	PBN-82-02AB,&C	24	PBM-85-02		S1147
8	PBN-89-10A,B,C,&D	25	PBN-89-03B&C	37	SPN-89-04B&C
9	PBM-82-02		PBN-85-03A		S1148, SPN-91-04D
10	S1144	26	PBM-89-05	38	S1102, S1103, S1149
11	PBM-82-01	27	PBM-85-04	39	S1152A&B
12	PBM-82-03	28	PBM-85-05	40	SPN-89-05A&B
13	PBM-82-04	29	PBM-89-08	41	S1110
14	PBM-82-05	30	PBN-89-04B&C	42	S1104, S1105, S1106
15	PBN-82-05A,B,&C		PBN-85-04A	43	S1109
16	S1117	31	PBM-89-07	44	S1115, S1116
17	PBN-82-03A,B,&C	32	PBN-91-06C&D	45	LOM-91-01
	S1146		PBM-85-06	46	LOM-91-02
18	PBN-82-04A,B,&C	33	PBN-89-12A&B		
19	PBM-85-01		PBN-91-12C&D		

APPROXIMATE SCALE IN FEET
0 1000 2000

LEGEND

SP 1 SETTLING PONDS AREA AND DESIGNATION

SS II SPOILS DISPOSAL AREA AND DESIGNATION

1 LOCATION OF SINGLE MONITORING WELL

3 LOCATION OF MONITORING WELL NEST

PBN-89-12B — SAMPLE LOCATION
NNDPA -/3.25
— COMPOUND CONCENTRATION IN SAMPLE (µg/L) FROM ROUND ONE OF SAMPLING (NOV/DEC 1991)
— COMPOUND CONCENTRATION IN SAMPLE (µg/L) FROM ROUND TWO OF SAMPLING (APR/MAY 1992)
— COMPOUND OF CONCERN

- = LESS THAN CERTIFIED REPORTING LIMIT (CRL)

NOTES:
1. ONLY DATA FROM WELLS IN WHICH EITHER 26DNT OR NNDPA WAS DETECTED ARE PRESENTED.
2. 24DNT WAS NOT DETECTED IN GROUNDWATER SAMPLES FROM ROUND ONE AND ROUND TWO.
3. BASE MAP FROM 300 SCALE SITE TOPOGRAPHIC PLAN PROVIDED BY OLIN CORPORATION.

FIGURE 3-23
26DNT AND NNDPA
DETECTED IN GROUNDWATER
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9211045D d h

TABLE 4-1
HUMAN HEALTH CONTAMINANTS OF CONCERN
DETERRENT BURNING GROUND

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	EXPOSURE POINT CONCENTRATION µg/g
24DNT	37,000
26DNT	1,400
3NT	6.9
AS	7.88
B2EHP	4.35
C6H6	5.25
CR	13.2
DNBP	62
FANT	0.139
MEC6H5	0.138
NI	10.2
NIT	18.7
NNDPA	2,200
PHANTR	0.183
PYR	0.144
SO4	5.19
TXYLEN	0.001
ZN	26.7

Notes:

Exposure point concentration is the maximum detected concentration.
µg/g = micrograms per gram, equivalent to parts per million (ppm)

Full compound names are identified in the USAEC Chemical Code List located behind the glossary of acronyms.

TABLE 4-2
CLEAN-UP STANDARDS
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	PROTECTION OF GROUNDWATER[1] (mg/kg)	PROTECTION OF HUMAN HEALTH[2] (mg/kg)
Organics		
24DNT	0.00002	4.29
26DNT	0.0002	4.29
3NT	-	NHD
13DMB	-	NHD
B2EHP	NI	208.57
C6H6	NI	100.35
DEP	NPAL	834,400
DNBP	NPAL	NHD
FANT	-	41,270
MEC6H5	NI	208,537
NNDPA	NI	595.92
PHANTR	-	41,720
PYR	-	31,290
TXYLEN	NI	> 1,000,000
Metals		
AS	0.068	1.6
CR	1.666	211.95
NI	-	-
ZN	80.800	312,900

Notes:

NPAL = No Wisconsin Preventive Action Limit (unable to calculate soil concentration that is protective of groundwater).
NHD = No human toxicity data.
NI = No impact on groundwater.
\- = Not a human health contaminant of concern.
1 Protective of groundwater per the Proposed Chapter NR 720.
2 Protective of Human Health per the Proposed Chapter NR 720.

Full compound names are identified in the USAEC Chemical Code List located behind the glossary of acronyms.

Table 4-3
Comparison of Groundwater to Standards
Units: $\mu g/L$
Deterrent Burning Ground

Feasibility Study
Badger Army Ammunition Plant

Compound of Potential Concern	Frequency of Detection (c)	Maximum Detected Concentration	Minimum Detected Concentration	SDWA (1)		WI Groundwater Standards (2)	
				MCL	MCLG	ES	PAL
111TCE	8:80	12.1	3.07	200	200	200	40
112TCE	5:8	2.31	0.365	5	3	0.6	0.06
26DNT	2:80	2.17	1.29	-	-	0.05	0.005
BA	56:56	760	13.7	2,000	2,000	2,000	400
BE	10:80	1.14	0.362	4	-	4(d)	0.4(d)
CD	1:80	3.23	-	5	5	5	0.5
CL	80:80	69,000	1,450	250,000(a)	-	250,000(e)	125,000(e)
CR	38:80	140	4.98	100	100	100	10
CU	25:80	77.2	4.7	TT	1,300	1,300	130
HG	1:81	4.25	-	2	2	2	0.2
MN	21:56	480	7.85	50(a)	-	50(e)	25(e)
NA	38:56	33,000	2,890	20,000(b)	-	-	-
NIT	80:80	16,000	130	10,000	10,000	10,000	2,000
NNDPA	3:80	16.7	1.02	-	-	7	0.7
PB	4:80	8.61	5.94	TT	0	15	1.5
NI	8:80	24.4	9.45	100	100	-	-
SE	2:80	5.01	4.03	50	50	50	10
SO4	80:80	630,000	9,500	250,000(a)	-	250,000(e)	125,000(e)

continued

TABLE 4-3
COMPARISON OF GROUNDWATER TO STANDARDS
UNITS: μg/L
DETERRENT BURNING GROUND

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND OF POTENTIAL CONCERN	FREQUENCY OF DETECTION (c)	MAXIMUM DETECTED CONCENTRATION	MINIMUM DETECTED CONCENTRATION	SDWA (1)		WI GROUNDWATER STANDARDS (2)	
				MCL	MCLG	ES	PAL
V	13:56	19.1	4.14	-	-	-	-
ZN	21:80	3,900	20.8	5,000(a)	-	5,000(e)	2,500(e)

Sources:

(1) U.S. Environmental Protection Agency (USEPA), 1991, "Fact Sheet: National Primary Drinking Water Standards." Office of Water, Washington, D.C., August 1991; USEPA, 1991, "Fact Sheet: National Secondary Drinking Water Standards," Office of Water, Washington, D.C., September 1991; and USEPA, 1990, "National Primary and Secondary Drinking Water Regulations; Synthetic Organic Chemicals and Inorganic Chemicals, Final Rule," 57FR31776, July 17, 1992 (see Subsection 3.6 for details).

(2) Wisconsin Administrative Code, Chapter NR 140.10, Table 1 (see Subsection 3.6 for details).

Notes:

(a) Secondary drinking water standard, suggested level.
(b) Reporting level. Monitoring is required and data is reported to health officials to protect individuals on restricted sodium diet.
(c) A:B frequency detector where "A" is the number of samples where that compound was detected and "B" is the number of samples analyzed for that compound.
(d) Interim State Drinking Water Standard
(e) Value for protection of public welfare (usually aesthetic concerns) rather than for protection of human health

μg/L = micrograms per liter
SDWA = Safe Drinking Water Act
MCL = Maximum Contaminant Level
MCLG = Maximum Contaminant Level Goal
WI = Wisconsin
ES = Enforcement Standard
PAL = Preventive Action Limit
TT = Treatment technique requirement in effect
Copper action level - 1300 μg/L
Lead action level - 15 μg/L

Full compound names are identified in the USAEC Chemical Code List located behind the glossary of acronyms.

TABLE 4-4
REMEDIATION GOALS
DETERRENT BURNING GROUND

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	DETECTION LIMIT (mg/kg)	MAXIMUM DETECTED CONCENTRATION (mg/kg)	MAXIMUM BACKGROUND CONCENTRATION (mg/kg)	PROTECTION OF GROUNDWATER SOIL TARGET CONCENTRATION (mg/kg)	PROTECTION OF HUMAN HEALTH (mg/kg)	PROTECTION OF ECOLOGICAL RECEPTORS (mg/kg)	REMEDIATION GOAL (mg/kg)
Organics							
24DNT	1.0	37,000	-	.084	4.29	-	1.0[1]
26DNT	1.0	1,400	-	690.368	4.29	-	4.29[2]
NNDPA	1.0	5,200	-	NI	595.92	-	595.92
Metals							
AS	0.1	7.88	<2.5	0.224	1.6	-	2.5[3]
CR	0.7	13.2	10.4	1.24	211.95	-	10.4[3]

Notes:

mg/kg = milligrams per kilogram
NI = No impact on groundwater.
1 Detection limit
2 Protective of human health per NR 720 Rule.
3 Background concentration; which is greater than NR 720 concentration for protection of groundwater.

Full compound names are identified in the USAEC Chemical Code List located behind the glossary of acronyms.

Table 4-5
Remediation Goals
Deterrent Burning Ground Groundwater

Feasibility Study
Badger Army Ammunition Plant

Compound	Maximum Concentration Detected ($\mu g/L$)	Remediation Goal ($\mu g/L$)	Rationale
26DNT	2.17	0.005	WPAL
112TCE	2.31	0.6	WPAL
BA	760	400	WPAL
BE	1.14	0.4	interim WPAL
CD	3.23	0.5	WPAL
CR	140	10	WPAL
HG	4.25	0.2	WPAL
MN	480	25	WPAL[1]
NIT	16,000	2,000	WPAL
NNDPA	16.7	0.7	interim WPAL
PB	8.61	1.5	WPAL
SO4	630,000	125,000	WPAL[1]

Notes:

WPAL = Wisconsin Preventive Action Limit
$\mu g/L$ = micrograms per liter
[1] = Public Welfare Standards

Full compound names are identified in the USAEC Chemical Code List located behind the glossary of acronyms.

TABLE 4-6
GENERAL RESPONSE ACTIONS AND POTENTIAL REMEDIAL TECHNOLOGIES
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GENERAL RESPONSE ACTION	SOIL TECHNOLOGY	DESCRIPTION
No Action	None	No action. Site monitoring.
Minimal Action	Institutional Controls/ Education Programs	Zoning and deed restrictions on potentially contaminated areas. Educate public concerning site hazards.
Containment	Soil Cover	A layer of native soil is placed over the site. The thickness of the layer is sufficient to prevent direct contact and ingestion hazards associated with contaminated surface soil.
	Capping	Low-permeability cover (e.g., clay and soil; asphalt; clay and synthetic membrane covered with soil) is constructed over the site to provide a barrier to water infiltration and/or to prevent direct contact and ingestion hazards associated with contact of contaminated surface soil.
Excavation/Disposal	On-Site Landfill	Soil not regulated by RCRA Land Disposal Restrictions is excavated and disposed of in a secure on-site landfill constructed for that purpose.
	Off-Site Landfill	Soil not regulated by RCRA Land Disposal Restrictions is excavated, transported, and disposed of in a secure, existing landfill.
Soil Excavation/Treatment	On-Site Incineration	Soil is excavated and treated with a mobile incinerator which thermally destroys VOCs/ SVOCs in a direct-fired treatment unit.
	Off-Site Incineration	Soil is excavated and transported to a licensed incinerator which thermally destroys VOCs/SVOCs in a direct-fired treatment unit.
	Solvent Extraction	Soil is excavated and mixed with a chemical solvent in a batch mixer. Soil settles out and solvent/contaminant is decanted off. The contaminant is then separated from the solvent to produce an effluent stream of concentrated contaminant.

continued

TABLE 4-6
GENERAL RESPONSE ACTIONS AND POTENTIAL REMEDIAL TECHNOLOGIES
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GENERAL RESPONSE ACTION	SOIL TECHNOLOGY	DESCRIPTION
Soil Excavation/Treatment cont.	Stabilization/Solidification	Soil is excavated and mixed with a setting agent (e.g., cement, fly ash, lime) which entraps contaminants in a solid, low-permeability mass.
	Anaerobic Thermal Process	Soil is excavated and treated by a mobile unit which uses high temperatures in an anaerobic environment to desorb VOCs/SVOCs from the soil. The contaminants are condensed into a liquid waste stream.
	Soil Washing	Soil is excavated and mixed with an aqueous-based washing solution in a series of high-energy mobile washing units. VOCs/SVOCs and metals can be separated from soil. Washing solution is recycled.
	Vitrification Thermal Process	Soil is excavated and treated in a reactor which heats soil to its melting point then allows it to cool into solid, glass-like structure. Organics are either trapped in the matrix, destroyed, or volatilized.
	Composting	Soil is excavated and treated by biological degradation. Studies show treatment of DNTs to 30 mg/kg.
In Situ Treatment	Stabilization/Solidification	A solidifying agent is added in place to contaminated soil to form a monolithic product in which contaminants are entrapped within a solidified mass.
	Vitrification	High voltage current is passed through the contaminated zone until complete meltdown of soils has occurred. The high temperatures generated during meltdown pyrolyze and eventually combust organic constituents.

continued

TABLE 4-6
GENERAL RESPONSE ACTIONS AND POTENTIAL REMEDIAL TECHNOLOGIES
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GENERAL RESPONSE ACTION	SOIL TECHNOLOGY	DESCRIPTION
In Situ Treatment cont.	Soil Flushing	Aqueous-based washing solution is applied at the ground surface. Contaminants are removed from soil particles and held in the liquid phase as the solution infiltrates the soil. Solution containing the contaminants is removed through extraction wells after reaching the water table.

Note:

RCRA = Resource Conservation and Recovery Act
SVOC = semivolatile organic compound
VOC = volatile organic compound

Table 4-7
Remedial Technology Screening
Deterrent Burning Ground Soils

Feasibility Study
Badger Army Ammunition Plant

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
No Action	• Easily implemented. • No costs would be incurred with this option other than for monitoring.	• Does not reduce exposure potential for human or environmental receptors. • Would not reduce mobility, toxicity, or volume of contaminants.	Eliminated	Not protective of human health or the environment.
Institutional Controls/ Education Programs	• Reduces exposure potential for human and some environmental receptors. • Easily implemented. • Low potential for exposure to contaminants during implementation. • Minimal impact to environment during implementation.	• Would not reduce mobility, toxicity, or volume of contaminants. • Long-term monitoring and maintenance would be required. • Long-term liability associated with waste.	Retained	Institutional controls would reduce the potential for direct contact and ingestion by humans.
Soil Cover	• Reduces exposure potential for human receptors. • Not subject to RCRA Land Disposal Restrictions. • Easily implemented.	• Would not reduce mobility, toxicity, or volume of contaminants. • Uncertain design life. • Long-term monitoring and maintenance would be required. • Long-term liability associated with waste.	Retained	Soil cover would reduce direct contact and ingestion by human receptors.

continued

TABLE 4-7
REMEDIAL TECHNOLOGY SCREENING
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Capping	• Reduces exposure potential for human receptors. • No secondary wastes produced. • Commonly used method for remediation.	• Would not reduce mobility, toxicity, or volume of contaminants. • Uncertain design life. • Provides no advantage over a soil cover. • Long-term monitoring and maintenance would be required. • Long-term liability associated with waste.	Retained	Cap would reduce the potential for direct contact and ingestion by human receptors and reduce leaching of contaminants from subsurface soil to groundwater.
On-Site Landfill	• No secondary wastes produced. • Contaminants may be relocated to a more stable, contained, lower exposure potential environment. • No transportation of waste over public roads.	• Would not reduce toxicity, or volume of contaminants. • RCRA Land Disposal Restrictions may limit wastes eligible for disposal. • Long-term monitoring and maintenance would be required. • Long-term liability associated with landfilled waste.	Eliminated	Obtaining regulatory approval for a special waste landfill at BAAP would likely be difficult due to proximity to regional aquifer used as a drinking water source.

continued

TABLE 4-7
REMEDIAL TECHNOLOGY SCREENING
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Off-Site Landfill	• Widely used and easily implemented technology. • No wastes/treatment residuals remaining on site. • Contaminants may be relocated to a more stable, contained, lower exposure potential environment. • Relatively little mobilization effort and cost. • Experienced excavation contractors available.	• Would not reduce toxicity or volume of contaminants. • RCRA Land Disposal Restrictions may limit wastes eligible for disposal. • Limited landfill capacity nationwide. • Transportation and landfilling costs may be expensive. • Long-term liability associated with landfilled wastes.	Retained	Could be used for direct disposal of soils or as an option for disposal of treatment residuals.
On-site Incineration	• Destruction and removal efficiencies of greater than 99.99%, thus reducing volume of contaminants. • Widely used and demonstrated for treating organics at full-scale. • Mobile units are available.	• Treatment of volatile metals collected by air pollution equipment may be required. • Trial burns would be required to receive permits to operate.	Retained	Capable of treating SVOCs including DNTs in the soil at the DBG.
Off-Site Incineration	• Destruction and removal efficiencies of greater than 99.99%, thus reducing volume of contaminants. • Widely used and demonstrated for treating VOCs/SVOCs at full-scale. • No long-term monitoring or maintenance required. • Experienced vendors are available.	• Treatment of metals remaining in soil may be required. • Limited capacity at RCRA-permitted incinerators. • High cost associated with transportation and incineration of wastes.	Retained	Capable of treating SVOCs including DNTs in the soil at the DBG. May be cost effective for treating small volumes of soil.

continued

TABLE 4-7
REMEDIAL TECHNOLOGY SCREENING
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Solvent Extraction	• Contaminants are transferred into a manageable liquid waste stream. • Capability for treating soils contaminated with VOCs/SVOCs and metals. • Demonstrated full-scale performance for removal of organics from sludge.	• Would not reduce mobility, toxicity, or volume of contaminants. • Concentrated contaminant waste stream requires further treatment. • Limited operating experience with BAAP-specific contaminated soils. • Depending on process, residual extraction solvent may remain in soil and would require treatment. • Treatability studies required to determine potential for treating DNT-contaminated soil.	Eliminated	Solvent extraction has been demonstrated primarily on sludges; there is very little experience with contaminated soils. This technology would not offer significant advantages over other proven technologies.
Stabilization/ Solidification	• Reduces mobility of metals. • Technology is relatively simple and easily implemented. • Technology is reliable and has been demonstrated at full-scale for treating inorganics. • Experienced vendors are available.	• Would not reduce toxicity or volume of contaminants. • Volume of contaminated media potentially increased by 20-30%. • Pre-treatment for organics potentially required. • Long-term performance for treatment of VOC/SVOC wastes not demonstrated. • Treatability studies would be required.	Eliminated	Technology not demonstrated for VOC/SVOC wastes.

continued

TABLE 4-7
REMEDIAL TECHNOLOGY SCREENING
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Anaerobic Thermal Process	• Contaminants are transferred into a manageable liquid waste stream. • May not require an incinerator permit to operate. • Demonstrated full-scale performance for removal of organics from soil.	• Would not reduce mobility, toxicity, or volume of contaminants. • Concentrated contaminant waste stream requires further treatment. • Treatment of metals remaining in soil may be required. • Treatment of volatile metals collected by air pollution control equipment potentially required. • Limited number of transportable units available. • Treatability studies would be required.	Eliminated	ATP technology not applicable to explosive contaminated soil.

continued

TABLE 4-7
REMEDIAL TECHNOLOGY SCREENING
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Soil Washing	• Wide application to varied waste groups. • Demonstrated at full-scale for removal of organics from soil. • Mobile units are available.	• Potentially hazardous chemicals may be brought on site to be used in process. • Concentrated contaminant waste stream requires further treatment. • Potential difficulty in removing washing solution from treated soil. • Limited effectiveness for treating soil with high humic content and high fine-grained clay fraction. • Treatability studies would be required to determine potential for treating DNT-contaminated soil.	Retained	Capable of treating soil contaminated with VOCs/SVOCs.

continued

TABLE 4-7
REMEDIAL TECHNOLOGY SCREENING
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Vitrification	• Reduces mobility, toxicity, and volume of contaminants. • Effective for VOCs/SVOCs and metals.	• Treatment may be required to destroy volatile organics in the vapor phase. • Vitrified soil would require disposal. • Would not be effective on soils with high moisture content. • Process is very energy intensive. • Not demonstrated at the full-scale level for treating DNTs. • Mobile units not available. • Treatability studies would be required to determine potential for treating DNT-contaminated soil.	Eliminated	Technology not demonstrated at full-scale level for treatment of DNT contaminated soils.
Composting	• Reduces mobility, toxicity, and volume of contaminants. • Recent full-scale operations show successful DNT treatment.	• Treatability studies would be required. • 5 to 7 acres would be required to implement.	Retained	Technology demonstrated for DNTs.

continued

TABLE 4-7
REMEDIAL TECHNOLOGY SCREENING
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
In Situ Stabilization/ Solidification	• Reduces mobility of contaminants. • Technology has been demonstrated at pilot-scale for treating metals and VOCs/SVOCs. • Not subject to RCRA Land Disposal Restrictions.	• Volume of contaminated media increased. • High concentrations of VOC/SVOC contaminants may interfere with the setting agent. • Reagent/waste ratios are difficult to control. • Not demonstrated at full-scale. • Long-term performance for treatment of VOC/SVOC wastes not demonstrated. • Long-term monitoring of the groundwater will be required. • Treatability studies would be required.	Eliminated	Technology not fully proven for the treatment of VOCs/ SVOCs

continued

TABLE 4-7
REMEDIAL TECHNOLOGY SCREENING
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
In Situ Vitrification	• Reduces mobility, toxicity, and volume of contaminants. • Effective for VOCs/SVOCs and metals. • Not subject to RCRA Land Disposal Restrictions.	• Treatment may be required to destroy volatile organics in the vapor phase. • Would not be effective on soils with high moisture content. • Process is very energy intensive. • Vendors not currently available. • Long-term groundwater monitoring would be required. • Treatability studies would be required. • Not demonstrated at the full-scale level for hazardous wastes.	Eliminated	Technology not demonstrated at full-scale level for treatment of explosives.
Soil Flushing	• Effective for removal of VOCs from permeable soils. • Full-scale units are available. • Not subject to RCRA Land Disposal Restrictions.	• Difficulty in treating complex waste mixtures. • Potential for uncontrolled migration of contaminants to groundwater. • Limited effectiveness for treating soil with high humic content and high fine-grained clay fraction. • Treatability studies would be required.	Eliminated	Should not be used where groundwater remediation is not planned. Would result in spreading contamination into a previously uncontaminated media (i.e., groundwater).

Notes:

DBG = Deterrent Burning Ground
DNT = Dinitrotoluene
VOC = volatile organic compound
RCRA = Resource Conservation and Recovery Act
BAAP = Badger Army Ammunition Plant
SVOC = semivolatile organic compound

TABLE 4-8
REMEDIAL TECHNOLOGIES RETAINED FOR REMEDIAL ALTERNATIVES DEVELOPMENT
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

MINIMAL ACTION	CONTAINMENT	EXCAVATION/DISPOSAL	SOIL EXCAVATION AND TREATMENT
Institutional Controls/ Education Programs	Soil Cover Capping	Off-site Landfill	On-Site Incineration Off-Site Incineration Composting Soil Washing

TABLE 4-9
GENERAL RESPONSE ACTIONS AND POTENTIAL REMEDIAL TECHNOLOGIES
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GENERAL RESPONSE ACTION	GROUNDWATER TECHNOLOGY	DESCRIPTION
No Action	Groundwater Monitoring	Perform water quality analyses to monitor contaminant migration and assess future environmental impacts.
Minimal Action	Institutional Controls/ Education Programs	Restrictions on use of contaminated groundwater. Educate public concerning site hazards.
Containment	Slurry Wall	Placement of a low-permeability barrier to restrict groundwater migration. Should include a cover system to reduce infiltration.
Collection	Groundwater Extraction Wells	Installation of several strategically located pumping wells to collect contaminated groundwater for treatment.
Treatment	UV/Oxidation	Oxidize VOC/SVOC contaminants in extracted groundwater through simultaneous application of UV light and ozone or hydrogen peroxide.
	Air Stripping	Reduce concentrations of VOCs through intimate contact of extracted groundwater with air. Water descends a packed column while air is forced up the column to promote mass transfer of organics from aqueous to gaseous phase.
	Carbon Adsorption	Reduce concentrations of aqueous or gaseous phase VOCs/SVOCs through adsorption onto granular activated carbon. May be used as a polishing step for treatments such as air stripping to further reduce VOC/SVOC concentrations in groundwater or to capture VOCs/SVOCs in air stripper emissions. Process produces a concentrated waste stream requiring further treatment.
	Resin Adsorption	Contaminants are transferred from the dissolved state to the surface of the resin. Resin can be regenerated by removing the contaminants with steam or solvent. Process produces a concentrated waste stream requiring further treatment.
	UV/Reduction	Reduce chlorinated compounds in extracted groundwater through simultaneous application of UV light and a proprietary liquid catalyst.

continued

TABLE 4-9
GENERAL RESPONSE ACTIONS AND POTENTIAL REMEDIAL TECHNOLOGIES
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GENERAL RESPONSE ACTION	GROUNDWATER TECHNOLOGY	DESCRIPTION
In Situ Treatment	In Situ Biological	Introduce nutrients and oxygen or methane into the groundwater using a matrix of extraction wells and recirculation techniques.
Discharge	Off-Site Water Treatment Facility	Off-site disposal of extracted groundwater to a POTW. Groundwater would require transport by means of a force main and/or gravity feed sewer or by truck to the POTW.
	Groundwater Reinjection	Reinject treated groundwater using a series of wells and pumps. Can be used to enhance plume removal and accelerate remediation.
	Discharge to Surface Water	Discharge treated groundwater directly to nearby surface water body. Transport groundwater by means of force or gravity main.

Notes:

POTW = Publicly Owned Treatment Works
UV = ultraviolet
VOCs = volatile organic compounds
SVOCs = semivolatile organic compounds

TABLE 4-10
REMEDIAL TECHNOLOGY SCREENING
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Groundwater Monitoring	• Monitors short- and long-term effectiveness of remedial technologies when used during and after remediation.	• Does not reduce exposure potential for human receptors. • Would not reduce mobility, toxicity, or volume of contaminants when used alone.	Retained	Not protective of human health. Required component of groundwater remediation.
Institutional Controls/ Educational Programs	• Reduces exposure potential for human receptors. • Easily implemented.	• Would not reduce mobility, toxicity, or volume of contaminants. • May require future groundwater treatment.	Retained	Protective of human health and easily implemented.
Slurry Wall	• May reduce mobility of contaminants present in groundwater.	• Current construction methods/equipment are limited to a depth of 200 feet below ground surface. • Containment would not reduce the toxicity or volume of contaminants in groundwater. • Contaminants may degrade slurry wall material. • Difficult to implement in the aquifer at the DBG without impacting the regional aquifer.	Eliminated	Not particularly effective or implementable at the DBG because of the locally perched aquifer.
Groundwater Extraction Wells	• Groundwater extraction systems have been successfully implemented.	• Wells must be strategically located so that cones of depression intersect and capture all contaminated groundwater, without impacting the regional aquifer.	Retained	Groundwater extraction wells required for pump and treat alternatives.

continued

TABLE 4-10
REMEDIAL TECHNOLOGY SCREENING
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
UV/Oxidation	• Treatment provides permanent on-site destruction of VOCs/SVOCs into carbon dioxide and water, or nontoxic intermediates. • No air emissions or sludge is produced during the treatment process. • Destruction of VOCs and DNTs proven during full-scale operation.	• Treatability study should be performed prior to full-scale design to determine operating parameters and pretreatment requirements necessary to optimize operating efficiency.	Retained	Retained for treatment of VOCs/SVOCs in DBG groundwater.
Air Stripping	• Treatment would reduce the volume of contaminants in groundwater. • Air Stripping is a proven and reliable technology for treatment of VOCs.	• Off-gases produced during remediation may require collection/treatment/ disposal. • Treatment is not effective for compounds with low volatility. • Pretreatment for the removal of inorganics required to prevent fouling of air-stripper system. • Post-treatment by carbon adsorption may be required to meet discharge limits.	Retained	Retained for treatment of VOCs in DBG groundwater.

continued

TABLE 4-10
REMEDIAL TECHNOLOGY SCREENING
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Carbon Adsorption	• Treatment effectively removes organic material from groundwater by sorption. • Technology is reliable and has been demonstrated for treating VOCs/SVOCs at full-scale. • Carbon adsorption could be implemented as a polishing step after air stripping to meet discharge requirements.	• Suspended solids may require removal prior to treatment to avoid clogging carbon bed. • Spent carbon from the adsorption process would require disposal or regeneration.	Retained	Retained for treatment of organics in DBG groundwater.
Resin Adsorption	• Treatment would reduce the volume of chemicals in groundwater. • Removes metals and VOCs/ SVOCs from the waste water stream. • Capable of treating high flows.	• Process concentrates contaminants within the resin column, necessitating regeneration or disposal of the resin. • Reliability of this technology has not been demonstrated, particularly for groundwater treatment.	Retained	Retained for treatment of VOCs/SVOCs in DBG groundwater.
UV/Reduction	• Treatment provides permanent on-site destruction of chlorinated compounds. • No air emissions or sludge is produced during the treatment process.	• Only partial destruction of DNTs. • Treatability study should be required prior to full-scale design to determine operating parameters and pre-treatment requirements. • No full-scale units in operation.	Retained	Retained for treatment of chlorinated compounds in DBG groundwater.

continued

TABLE 4-10
REMEDIAL TECHNOLOGY SCREENING
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
In situ Biological Treatment	• Treatment would reduce volume, mobility, and toxicity, of contaminants present in groundwater. • No air emissions or secondary waste streams are produced. • Recirculation equipment is off-the-shelf.	• Significant time and expense for laboratory degradation studies and field demonstrations. • DNTs and chlorinated VOCs/SVOCs can be difficult to treat. • Parameters (e.g., temperature, pH, nutrients, and oxygen) for optimal microorganism growth can be difficult to maintain. • Poor migration of micro-organisms in the elevated aquifer. • Injection wells are susceptible to plugging by chemical precipitation of nutrients.	Eliminated	Not likely to effectively treat contaminants in the DBG groundwater (especially DNT and metals).
Off-Site Water Treatment Facility	• If sewer connection is nearby, this can be a relatively inexpensive discharge option.	• Approval by POTW, community, and WDNR may be difficult.	Eliminated	Discharge to surface water is the preferred option.
Groundwater Reinjection	• Groundwater not meeting clean-up standards may be reinjected upgradient for further treatment via pump-and-treat technology.	• Infiltration of treated groundwater could affect the migration of contaminants. • Reinjection of water into the plume's path may alter the extraction system's ability to collect contaminated groundwater.	Eliminated	Discharge to surface water is the preferred option.

continued

TABLE 4-10
REMEDIAL TECHNOLOGY SCREENING
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Discharge to Surface Water	• Construction of a discharge pipe to Lake Wisconsin would be easily implemented.	• Discharge water must meet applicable discharge standards developed by WDNR.	Retained	IRM facility currently discharges to Lake Wisconsin, therefore, obtaining regulatory approval is not expected to be difficult.

Notes:

DNT = Dinitrotoluene
IRM = Interim Remedial Measure
DBG = Deterrent Burning Ground
VOCs = Volatile organic compounds
WDNR = Wisconsin Department of Natural Resources
UV = Ultraviolet
POTW = Publicly Owned Treatment Works

TABLE 4-11
REMEDIAL TECHNOLOGIES RETAINED FOR REMEDIAL ALTERNATIVES DEVELOPMENT
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

MINIMAL ACTION[1]	COLLECTION & TREATMENT[1]	DISCHARGE[1]
Institutional Controls/Education Programs	Groundwater Extraction Wells UV/Oxidation Air Stripping Carbon Adsorption Resin Adsorption UV/Reduction	Surface Water

Notes:

1 Groundwater monitoring would be used in conjunction with these technologies.

UV = ultraviolet

TABLE 4-12
IDENTIFICATION OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVES	ACTION							
	MINIMAL ACTION	SOIL COVER	CAPPING	OFF-SITE LANDFILL	SOIL WASHING	ON-SITE INCINERATION	OFF-SITE INCINERATION	COMPOSTING
Subsurface Soils								
DBG-SB1	X							
DBG-SB2			X					
DBG-SB3				X				
DBG-SB4					X			
DBG-SB5							X	
DBG-SB6					X		X	
DBG-SB7						X		
DBG-SB8		X						X

Note:

X = Identified technology is a component of alternative.

TABLE 4-13
DEVELOPMENT OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Remedial Action Objectives:

(1) Prevent concentrations of 24DNT, 26DNT, NNDPA, and AS in subsurface soil which exceed clean-up standards for protection of human health from becoming available through incidental ingestion or inhalation to potential human receptors.

(2) Prevent concentrations of 24DNT, 26DNT, AS, and CR which exceed clean-up standards for protection of groundwater from degrading groundwater quality.

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
DBG-SB1: Minimal Action	• Post warning signs. • Institutional Controls. Implement zoning and deed restrictions to prohibit excavation and use of groundwater within and around the site. • Education programs. • Groundwater Monitoring. Perform water quality analyses to monitor contaminant migration and assess future environmental impacts. • Five-year site reviews.
DBG-SB2: Capping	• Install RCRA cap to reduce leaching of contaminants to groundwater and to prevent direct contact or incidental ingestion by ecological or human receptors. • Surface water management to minimize erosion of cover system. • Post-closure plan development to monitor, maintain, and inspect site. • Institutional Controls. Implement zoning and deed restrictions to protect RCRA cap from invasive activities. • Groundwater monitoring. • Five-year site reviews.
DBG-SB3: Off-Site Landfill	• Obtain appropriate permit(s). • Excavate contaminated soil. • Confirmatory sampling to ensure wastes have been removed. • Backfill excavation with clean fill. • Sample and analyze soil to ensure it meets landfill acceptable criteria. • Transport soil to off-site landfill.

continued

TABLE 4-13
DEVELOPMENT OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
DBG-SB4: Soil Washing	• Obtain appropriate permit(s). • Mobilize soil washing equipment to site. • Excavate contaminated soil. • Confirmatory sampling to ensure wastes have been removed. • Stockpile wastes at treatment area. • Wash contaminated soil. • Transport secondary waste streams off site for treatment. • Backfill excavations with treated soil.
DBG-SB5: Off-Site Incineration	• Obtain appropriate permit(s). • Excavate contaminated soils. • Confirmatory sampling to confirm wastes have been removed. • Sample and analyze soil for incinerator-required parameters. • Backfill excavations with clean fill. • Transport soil to off-site incinerator
DBG-SB6: Off-Site Incineration, Soil Washing	• Obtain appropriate permit(s). • Mobilize soil washing equipment to site. • Excavate "hot spot" soils. • Confirmatory sampling to confirm "hot spots" have been removed. • Sample and analyze soil for incinerator-required parameters. • Transport "hot spot" soil to off-site incinerator. • Excavate remaining contaminated soil. • Confirmatory sampling to confirm wastes have been removed.

continued

TABLE 4-13
DEVELOPMENT OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
DBG-SB6: Off-Site Incineration, Soil Washing (continued)	• Transport and stockpile wastes at treatment area. • Wash contaminated soil. • Transport secondary waste streams off site for treatment. • Backfill excavations with treated soil and clean fill.
DBG-SB7: On-Site Incineration	• Obtain appropriate permit(s). • Mobilize incinerator to site. • Excavate contaminated soils. • Confirmatory sampling to confirm wastes have been removed. • Transport and stockpile wastes at treatment area. • Incinerate soil. • Transport secondary waste streams off site for treatment. • Backfill excavations with treated soil and clean fill.
DBG-SB8: Composting, Soil Cover	• Obtain appropriate permit(s). • Mobilize equipment to site. • Excavate contaminated soils. • Confirmatory sampling to confirm wastes have been removed. • Transport and stockpile wastes at treatment area. • Blend and screen excavated soil. • Arrange soil into windrows and add amendment. • Backfill excavations with treated soils and clean fill. • Cover with soil layer.

Notes:

Full compound names are identified in the USAEC Chemical Code List located behind the glossary of acronyms.

VOC = volatile organic compound
SVOC = semivolatile organic compound
ATP = Anaerobic Thermal Processing

TABLE 4-14
SCREENING OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative DBG-SB1: Minimal Action: This alternative consists of institutional controls, educational programs, groundwater monitoring, and five-year site reviews. Fencing and warning signs would surround those areas identified as posing a risk to public health.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Public access to affected areas would be restricted. • Low potential for exposure to contaminants during implementation. • Institutional controls would reduce the potential for inappropriate future land use. • Educational programs would increase public awareness about contamination.	Advantages • Would be easy to implement because no remedial actions are required. • Services and material readily available.	Advantages • Cost includes administration of institutional controls, educational programs, and groundwater monitoring and maintenance.
Disadvantages • Would not reduce mobility, toxicity, or volume of contaminants.	Disadvantages • Not consistent with SARA's preference for treatment. • Long-term monitoring and maintenance would be required.	Disadvantages • Remedial actions, if required in the future, may be more costly if contamination migrates. • Long-term liability associated with waste.

CONCLUSION: The minimal action alternative is **retained** as a baseline for comparison with the remaining alternatives at the Deterrent Burning Ground.

continued

TABLE 4-14
SCREENING OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative DBG-SB2: Capping: This alternative consists of a RCRA cap to prevent direct contact and incidental ingestion of contaminated subsurface soil by human receptors and to reduce the potential for contaminants leaching to groundwater. This alternative also includes groundwater monitoring and five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • RCRA cap would reduce potential for direct contact or incidental ingestion of contaminants by receptors. • RCRA cap would be effective in reducing contact with contaminated soil by ecological receptors. • RCRA cap would reduce leaching of metals into groundwater. • Low potential for exposure to contaminants during implementation.	Advantages • Would be easy to implement. • RCRA cap would require minimal maintenance for the short term. • Equipment and supplies readily available.	Advantages • RCRA cap costs are relatively low compared to the treatment and disposal alternatives.
Disadvantages • Would not reduce the mobility, toxicity, or volume of contaminants. • RCRA caps may only be protective for the short term.	Disadvantages • Would require long-term monitoring and maintenance.	Disadvantages • Long-term liability associated with waste. • Long-term costs associated with inspection, monitoring, and maintenance.

CONCLUSION: Because this alternative has potential for achieving the remedial action objectives for protection of human health and groundwater and would be easily implemented, it is **retained** for detailed analysis.

continued

TABLE 4-14
SCREENING OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative DBG-SB3: Off-Site Landfill: This alternative consists of excavating contaminated soil, backfilling excavations with clean fill, and transporting the contaminated soil off site for disposal in a landfill.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives. • Disposal of contaminants in a secure landfill. • No significant short-term or long-term threat to human health and the environment.	Advantages • Long-term monitoring and maintenance provided by host landfill. • Surface soils are easily and rapidly removed with conventional grading equipment. • Excavation, transportation, and landfilling services are readily available. • No post-remediation monitoring or maintenance program required.	Advantages • No long-term costs associated with operation and maintenance of monitoring systems.
Disadvantages • Would not reduce the toxicity or volume of contaminants. • Excavation would increase the dermal contact risk for on-site workers.	Disadvantages • Contaminated soil may fail TCLP analysis for DNT, thus invoking RCRA Land Disposal Restrictions. • Contaminated soil which fails TCLP analysis for DNT would be rejected by landfill unless it is first treated. • Excavation would be required and clean backfill would be necessary.	Disadvantages • High cost for disposal in a RCRA-permitted landfill. • High cost for transportation of contaminated soil. • Long-term liability associated with landfilled wastes.

CONCLUSION: The volume of soil to be disposed is approximately 5,700 yd^3. Due to high cost and comparable on-site treatments available (if on-site incineration is used at PBG), this alternative has been **eliminated** from further consideration.

continued

TABLE 4-14
SCREENING OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative DBG-SB4: Soil Washing: This alternative consists of excavating and washing contaminated soil and backfilling the excavations with the treated soil.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • May achieve remedial action objectives. • Reduces the volume of contaminated soil. • Off-site treatment of contaminated waste stream would reduce contaminant mobility. • Eliminates long-term threat to human health and the environment.	Advantages • Soil washing a proven, reliable technology for treating varied waste groups. • Soil washing services are readily available. • No long-term monitoring and maintenance requirements. • Surface soils are easily and rapidly removed with conventional grading equipment.	Advantages • No long-term operation and maintenance costs. • No long-term liability. • Unit costs are lower than other treatment alternatives.
Disadvantages • Potential for direct human contact with contaminated soil during soil washing. • Treatability study required to determine effectiveness.	Disadvantages • Contaminants may be difficult to remove from fine-grained soils. • Depending on the soil gradation, the secondary waste stream may be a significant percentage of the original volume. • Fine soil particles are difficult to remove from the washing solution. • RCRA permits may be difficult to obtain if required. • Not effective without the use of surfactants, which may be difficult to remove from treated soil.	Disadvantages • Treating the secondary waste stream could significantly increase overall cost.

CONCLUSION: Because of its versatility in treating VOCs/SVOCs and metals alike, soil washing is **retained** for further evaluation.

TABLE 4-14
SCREENING OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative DBG-SB5: Off-Site Incineration: This alternative consists of excavating contaminated soil and transporting it to an off-site incinerator.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives. • Incineration would reduce the mobility, toxicity, and volume of contaminants in the soil. • No significant short-term or long-term threat to human health and the environment. • Incineration has been historically chosen as the technology used for treating DNT-contaminated soils.	Advantages • Incineration is a proven, reliable technology for the treatment of explosives-contaminated soils. • Treatability studies would not be required because incineration is a well-proven technology for DNT-contaminated soils.	Advantages • No long-term costs associated with operation and maintenance of monitoring systems.
Disadvantages • Excavated soils would increase the dermal contact risk to on-site workers. • No more effective at meeting remedial objectives than DBG-SS4 or DBG-SS8.	Disadvantages • Excavation would be required; clean backfill would be necessary.	Disadvantages • Costs of treatment and transportation is considerably greater than other alternatives.

CONCLUSION: Although this alternative is a very effective treatment alternative for DNT-contaminated soils, it is not cost-effective compared to other treatment technologies and is therefore **eliminated** from further consideration.

TABLE 4-14
SCREENING OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative DBG-SB6: Off-Site Incineration, Soil Washing: This alternative consists of excavating grossly contaminated soil and transporting the soil to an off-site incinerator; and excavating and washing the remaining contaminated soil.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • May achieve remedial action objectives. • Soil remediation would reduce contaminant mobility, toxicity, and volume. • Eliminates long-term threat to human health and the environment.	Advantages • Off-site incineration is a proven, reliable technology for treatment of VOCs/SVOCs. • Excavation, transportation, off-site incineration services, and soil washing services and materials readily available. • Soil washing more likely to be effective on lower levels of contaminants. • No long-term monitoring and maintenance requirements.	Advantages • No long-term monitoring and maintenance costs to be incurred. • No long-term liability. • Cost for transportation of contaminated soil is approximately $60/yd^3. contaminants.
Disadvantages • Excavated soil would increase the dermal contact risk to on-site workers. • No more effective than DBG-SS4.	Disadvantages • Treatability tests would need to be performed for soil washing technology. • Surfactants must be used with soil washing and may be difficult to remove. • Excavation of "hot spots" requires clean backfill material.	Disadvantages • Costs higher than soil washing alone. • Treating soil washing secondary waste stream could significantly increase overall cost.

CONCLUSION: This alternative is no more effective than other treatment alternatives, but the cost may be substantially higher; therefore it is **eliminated** from further consideration.

continued

TABLE 4-14
SCREENING OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative DBG-SB7: On-Site Incineration: This alternative consists of excavating contaminated soil, treating the soil by on-site incineration, and backfilling the excavations with treated soil.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives. • Soil remediation would reduce contaminant mobility, toxicity, and volume of contaminants • Destruction efficiency potential of 99.99%.	Advantages • On-site incineration is a proven, reliable technology for treatment of VOCs/SVOCs. • On-site incineration services readily available. • Backfilling with treated soil, therefore very little, if any, clean backfill is necessary	Advantages • No long-term monitoring requirements. • No transportation costs to be incurred. • Costs are less than for off-site incineration.
Disadvantages • Fly ash that does not pass the TCLP test requires RCRA disposal. • Air emission controls are necessary and permits are required.	Disadvantages • Contaminated soil is expected to be RCRA characteristic hazardous waste and trial burns would be required for an on-site incinerator. • Sophisticated monitoring instrumentation is required to control the combustion process. • Permitting is required.	Disadvantages • Disposal of fly ash may be required. • Mobilization of mobile units is expensive; $600,000 to $1.2 million.

CONCLUSION: Incineration has been historically chosen for treatment of DNT-contaminated soils, and implementability and cost comparisons between on-site and off-site incineration for the quantity of soil to be remediated at this site allows this alternative to be **retained** for detailed analysis.

continued

TABLE 4-14
SCREENING OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative DBG-SB8: Composting, Soil Cover: This alternative consists of excavating contaminated soil, treating the soil on site by biodegradation, backfilling excavations with treated soil, and providing a soil cover over treated soils.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • May achieve remedial action objectives. • Remediation of contaminated soil would eliminate direct contact and incidental ingestion hazards. • Would reduce toxicity, mobility, and volume of contaminants.	Advantages • Composting is a demonstrated technology for low concentrations of DNTs.	Advantages • No costs associated with this technology for secondary treatment.
Disadvantages • Treatment only demonstrated to 30 mg/kg.	Disadvantages • No full-scale operations. • Treatability studies would be required.	

CONCLUSION: Because this alternative has potential for achieving remedial action objectives and includes treatment of contaminated soil, it is **retained** for detailed analysis.

Notes:

RCRA = Resource Conservation and Recovery Act
TCLP = Toxicity Characteristic Leaching Procedure
DNT = Dinitrotoluene
SARA = Superfund Amendments and Reauthorization Act

TABLE 4-15
SUMMARY OF REMEDIAL ALTERNATIVES SCREENING
DETERRENT BURNING GROUND SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE		STATUS
Alternative DBG-SB1:	Minimal Action	Retained for detailed analysis.
Alternative DBG-SB2:	Capping	Retained for detailed analysis.
Alternative DBG-SB3:	Off-site Landfill	Eliminated from detailed analysis.
Alternative DBG-SB4:	Soil Washing	Retained for detailed analysis.
Alternative DBG-SB5:	Off-site Incineration	Eliminated from detailed analysis.
Alternative DBG-SB6:	Off-site Incineration, Soil Washing	Eliminated from detailed analysis.
Alternative DBG-SB7:	On-Site Incineration	Retained for detailed analysis.
Alternative DBG-SB8:	Composting, Soil Cover	Retained for detailed analysis.

Table 4-16
Identification of Remedial Alternatives
Deterrent Burning Ground Groundwater

Feasibility Study
Badger Army Ammunition Plant

Alternatives	Action							
	Minimal Action	Groundwater Extraction Wells	UV/Oxidation	Air Stripping	Carbon Adsorption	Resin Adsorption	UV/Reduction	Discharge to Surface Water
DBG-GW1	X							
DBG-GW2		X		X	X			X
DBG-GW3		X	X	X	X			X
DBG-GW4		X		X	X			X
DBG-GW5		X		X	X	X		X
DBG-GW6				X	X		X	X

Note:

X = Identified technology is a component of alternative
UV = Ultraviolet

TABLE 4-17
DEVELOPMENT OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Remedial Action Objectives:

(1) Prevent further contamination of the elevated groundwater system.
(2) Prevent exposure to concentrations of 26DNT, 112TCE, NIT, BA, CD, PB, CR, and HG exceeding their respective WPALs.
(3) Prevent exposure to concentrations of BE and NNDPA above interim WPALs of 0.40 μg/L and 0.70 μg/L, respectively.
(4) Prevent exposure to concentrations of MN and SO4 exceeding secondary drinking water standards.

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
DBG-GW1: Minimal Action	• Institutional Controls. Implement zoning and deed restrictions to prohibit use of groundwater within and around the site. • Education programs. • Groundwater Monitoring. Perform water quality analyses to monitor contaminant migration and assess future environmental impacts. • Five-year site reviews.
DBG-GW2: Groundwater Extraction, IRM and Carbon Adsorption, Discharge to Lake Wisconsin	• IRM treatment facility. • Install groundwater extraction system. • Groundwater extracted, transported to the PBG and treat using the existing IRM facility and a new carbon adsorption facility. • Treated water discharged to Lake Wisconsin. • Effluent monitored as required by WDNR permit requirements. • Groundwater monitoring. Water quality analyses performed to monitor the progress of the cleanup. • Periodic reviews.
DBG-GW3: Groundwater Extraction, IRM and UV/Oxidation, Discharge to Lake Wisconsin	• Install groundwater extraction system. • Extract groundwater and treat using IRM facility and new UV/oxidation facility. • Discharge treated water to Lake Wisconsin. • Monitor effluent as required by WDNR permit requirements. • Groundwater monitoring. Perform water quality analyses to monitor the progress of the cleanup. • Five-year site reviews.

continued

TABLE 4-17
DEVELOPMENT OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
DBG-GW4: Groundwater Extraction, IRM and Air Stripping-Carbon Adsorption, Discharge to Lake Wisconsin	• Install groundwater extraction system. • Extract groundwater, transport to PBG treatment facility, and treat using the existing IRM facility and air stripping in series with carbon adsorption. • Discharge treated water to Lake Wisconsin. • Monitor effluent as required by WDNR permit requirements. • Groundwater monitoring. Perform water quality analyses to monitor the progress of the cleanup. • Five-year site reviews.
DBG-GW5: Groundwater Extraction, IRM and Resin Adsorption, Discharge to Lake Wisconsin	• Install groundwater extraction system. • Extract groundwater, transport to PBG treatment facility, and treat using the IRM facility and a new resin adsorption facility. • Discharge treated water to Lake Wisconsin. • Monitor effluent as required by WDNR permit requirements. • Groundwater monitoring. Perform water quality analyses to monitor the progress of the cleanup. • Five-year site reviews.
DBG-GW6: IRM and UV/Reduction, Carbon Adsorption	• Install groundwater extraction system. • Extract groundwater, transport to PBG, and treat using the IRM facility and a new UV/reduction carbon adsorption facility. • Discharge treated water to Lake Wisconsin. • Monitor effluent as required by WDNR permit requirements. • Groundwater monitoring. • Five-year site reviews.

Notes:

UV = ultraviolet
WDNR = Wisconsin Department of Natural Resources
IRM = Interim Remedial Measure
WES = Wisconsin Enforcement Standard
PBG = Propellant Burning Ground

TABLE 4-18
SCREENING OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative DBG-GW1: Minimal Action: This alternative consists of institutional controls, educational programs, groundwater monitoring, and five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives. • Institutional controls would reduce the potential for future groundwater use. • Educational program would increase public awareness about contaminated groundwater. • Site would be monitored for chemical migration.	Advantages • Would be easy to implement because no remedial actions are required. • Services and material readily available.	Advantages • Minimal cost for administration of institutional controls, and educational programs.
Disadvantages • Would not reduce mobility, toxicity, or volume of chemicals in groundwater. • Would not reduce the potential for off-site impacts due to chemicals in groundwater.	Disadvantages • Not consistent with SARA's preference for treatment. • Long-term monitoring and maintenance provisions would be required. • May require future groundwater remediation. • Future remedial actions may be more difficult to implement if horizontal and vertical extent of contaminated groundwater increase.	Disadvantages • Long-term costs associated with operation and maintenance of monitoring systems.

CONCLUSION: The minimal action alternative is **retained** as a baseline for comparison with the remaining alternatives for groundwater at the Deterrent Burning Ground.

continued

TABLE 4-18
SCREENING OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative DBG-GW2: IRM and Carbon Adsorption: This alternative consists of the continued use of the IRM treatment facility for groundwater remediation. The IRM treatment system includes treatment using carbon adsorption in series with air stripping, effluent monitoring, discharge to Lake Wisconsin, groundwater monitoring, and periodic reviews. A groundwater extraction system and transporting groundwater to the IRM facility are also included in this alternative.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Air stripping has the capability of removing contaminants that pass through carbon. • Carbon adsorption is a proven technology for treating DNTs.	Advantages • IRM treatment system is fully operational and is meeting WDNR permit requirements. • Contracts for operation and maintenance of the IRM system are in place. • Performance of carbon adsorption is well documented.	Advantages • Capital and operation and maintenance costs comparable to other water treatment processes.
Disadvantages • Does not achieve all remedial action objectives. • Extraction system may be intermittent. The elevated aquifer may be pumped dry, allowed to recharge, and pumped dry again.	Disadvantages • Spent carbon from the process requires regeneration. • Construction of extraction system is difficult due to low flows and thin aquifer. • Upgrading IRM system may require expansion of IRM treatment building. • New carbon facility required.	Disadvantages • Costs associated with monitoring program for groundwater and treatment facility discharge.

CONCLUSION: Because this alternative includes efficient treatment of groundwater contaminants, this alternative is **retained** for detailed analysis.

continued

TABLE 4-18
SCREENING OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative DBG-GW3: Groundwater Extraction, IRM and UV/Oxidation, Discharge: This alternative consists of groundwater extraction, trucking water to treatment facility at the PBG, treatment using IRM and UV/oxidation, effluent monitoring, discharge to Lake Wisconsin, groundwater monitoring, and five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • UV/oxidation provides permanent on-site destruction of organics into carbon dioxide and water, or nontoxic intermediates. • UV/oxidation unit produces no air emissions or sludge.	Advantages • Performance of UV/oxidation units is well documented. • Systems can accommodate a range of flow rates. • Experienced vendors are available to perform bench- and/or pilot-scale tests, provide equipment, and related services. • If the source of groundwater contamination is removed, long-term monitoring and maintenance provisions would not be required.	Advantages • Capital and operation and maintenance costs comparable to other water treatment processes. • No long-term operation and maintenance costs if source is removed. • If groundwater is combined with groundwater from the PBG and treated in the same facility, there would be no repeat construction costs.
Disadvantages • Unless the source is removed, will not achieve all remedial action objectives. • High suspended solids, total dissolved solids, carbonates/ bicarbonates, or metals (e.g., iron and manganese) may require pretreatment to maintain overall effectiveness. • Extraction system may operate intermittently. The elevated aquifer may be pumped dry, allowed to recharge, pumped dry again, etc.	Disadvantages • May require pretreatment for suspended solids, carbonate/ bicarbonates, and/or metals. • Construction of extraction system would be difficult due to low flows and a thin aquifer. • Ozone generator, if used for UV/ oxidation, is susceptible to failure without rigorous attention to operating parameters and maintenance. • New UV/oxidation facility required.	Disadvantages • Costs associated with monitoring program for groundwater and treatment facility discharge.

CONCLUSION: Because UV/oxidation was **eliminated** from detailed analysis for groundwater remediation at the PBG, it is eliminated from the detailed analysis at DBG as well. Costs would not be comparable if a separate treatment facility had to be constructed instead of combining waste streams.

continued

TABLE 4-18
SCREENING OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative DBG-GW4: Groundwater Extraction, IRM and Air Stripping - Carbon Adsorption, Discharge: This alternative consists of groundwater extraction, trucking groundwater to the treatment facility of the PBG, treatment using IRM and air stripping and carbon adsorption, effluent monitoring, discharge to Lake Wisconsin, groundwater monitoring, and five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages	Advantages	Advantages
• Air stripping is efficient for treatment of principal groundwater contaminants. • Carbon adsorption has the capability of removing contaminants that pass through the air stripper.	• Performance of air stripper and carbon adsorption units is well documented. • Experienced vendors are available to provide equipment and services. • Systems can accommodate a range of flow rates. • If the source of groundwater contamination is removed, long-term monitoring and maintenance provisions would not be required.	• Capital and operation and maintenance costs comparable to other water treatment processes. • Provided the source of groundwater contamination is removed, no long-term operation and maintenance costs. • If groundwater is combined with groundwater from the PBG and treated in the same facility, there would be no repeat construction costs.
Disadvantages	Disadvantages	Disadvantages
• Does not achieve all remedial action objectives. • No significant reduction in mobility volume or toxicity of groundwater contaminants because no definite source of contamination has been identified. • Extraction system may operate intermittently. The elevated aquifer may be pumped dry, allowed to recharge, pumped dry, etc.	• May require pretreatment for suspended solids, carbonate/bicarbonates, and/or metals to prevent fouling of air stripper packing and/or carbon. • Construction of extraction system would be difficult due to low flows and a thin aquifer. • Treatment (e.g., vapor-phase carbon) may be required for air stripper emissions. • Spent carbon from the process would require regeneration.	• Costs associated with monitoring program for groundwater and treatment facility discharge.

CONCLUSION: Because this includes efficient treatment of groundwater contaminants, it is **retained** for detailed analysis.

TABLE 4-18
SCREENING OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative DBG-GW5: Groundwater Extraction, IRM and Resin Adsorption, Discharge: This alternative consists of groundwater extraction, trucking groundwater to the treatment facility at the PBG, treatment using IRM and resin adsorption, effluent monitoring, discharge to Lake Wisconsin, groundwater monitoring, and five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages	Advantages	Advantages
• Resin adsorbents can be tailored to enhance selectivity for removal of a specific class of compounds (e.g., VOCs).	• Systems are capable of treating high flow rates. • If the source of groundwater contamination is removed, long-term monitoring and maintenance provisions would not be required. • Treatment is simplified with the use of only one treatment technology (i.e., resin adsorption) for all groundwater contaminants. • Resin can be regenerated without removing it from its column. • Experienced vendors are available to provide equipment and services.	• If groundwater is combined with groundwater from the PBG and treated in the same facility, there would be no repeat construction costs. • Capital and operation and maintenance costs comparable to other water treatment processes.
Disadvantages	Disadvantages	Disadvantages
• Does not achieve all remedial action objectives. • No significant reduction in mobility, volume, or toxicity of groundwater contaminants because a definite source of contamination has not been identified. • Extraction system may operate intermittently. The elevated aquifer may be pumped dry, allowed to recharge, pumped dry, etc.	• Demonstrated performance for treating contaminated groundwater with resin adsorption is limited. • Construction of extraction system would be difficult due to low flows and a thin aquifer. • May require pretreatment for suspended solids, carbonate/bicarbonates, and/or metals to prevent fouling of resin. • Spent resin from the process would require regeneration.	• Costs associated with monitoring program for groundwater and treatment facility discharge. • The use of specialized resins can significantly increase capital and/or operation and maintenance (replacement) costs.

CONCLUSION: Because this alternative includes efficient treatment of groundwater contaminants, it is **retained** for detailed analysis.

TABLE 4-18
SCREENING OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative DBG-GW6: Groundwater Extraction, IRM and UV/Reduction - Carbon Adsorption, Discharge: This alternative consists of groundwater extraction, trucking to the treatment facility at the PBG, treatment using IRM and UV/reduction - carbon adsorption, effluent monitoring, discharge to Lake Wisconsin, groundwater monitoring, five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • UV/reduction unit produces no air emissions or sludge. • UV/reduction provides permanent destruction of chlorinated compounds. • Carbon adsorption proven treatment for DNTs.	Advantages • Systems can accommodate a range of flow rates. • If the source of groundwater contamination is removed, long-term monitoring and maintenance provisions would not be required.	Advantages • Capital and operation and maintenance costs comparable to other water treatment processes.
Disadvantages • Does not achieve all remedial action objectives. • No significant reduction in mobility, volume, or toxicity of groundwater contaminants because a definite source of contamination has not been identified. • Extraction system may operate intermittently. The elevated aquifer may be pumped dry, allowed to recharge, pumped dry, etc.	Disadvantages • May require pretreatment for suspended solids, carbonate/ bicarbonates, and/or metals. • Construction of extraction system would be difficult due to low flows and a thin aquifer. • New UV/reduction facility required.	Disadvantages • Costs associated with monitoring program for groundwater and treatment facility discharge.

CONCLUSION: Because UV/reduction - carbon adsorption includes efficient treatment of groundwater contaminants, it was **retained** for detailed analysis.

Notes:

DBG	=	Deterrent Burning Ground
26DNT	=	26Dinitrotoluene
IRM	=	Interim Remedial Measure
PBG	=	Propellant Burning Ground
SARA	=	Superfund Amendments and Reauthorization Act
UV	=	ultraviolet
VOC	=	volatile organic compound
WDNR	=	Wisconsin Department of Natural Resources
WES	=	Wisconsin Enforcement Standard

TABLE 4-19
SUMMARY OF REMEDIAL ALTERNATIVES SCREENING
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	STATUS
Alternative DBG-GW1: Minimal Action	Retained for detailed analysis.
Alternative DBG-GW2: Groundwater Extraction, IRM and Carbon Adsorption	Retained for detailed analysis.
Alternative DBG-GW3: Groundwater Extraction, IRM and UV/oxidation-Discharge	Eliminated from further consideration.
Alternative DBG-GW4: Groundwater Extraction, IRM and Air Stripping-Carbon Adsorption, Discharge	Retained for detailed analysis.
Alternative DBG-GW5: Groundwater Extraction, IRM and Resin Adsorption, Discharge	Retained for detailed analysis.
Alternative DBG-GW6: Groundwater Extraction, IRM and UV/reduction - Carbon Adsorption	Retained for detailed analysis.

Note:

UV = ultraviolet

TABLE 4-20
SUMMARY OF CONTAMINATION ASSESSMENT
THROUGH REMEDIAL ALTERNATIVES SCREENING
DETERRENT BURNING GROUND

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

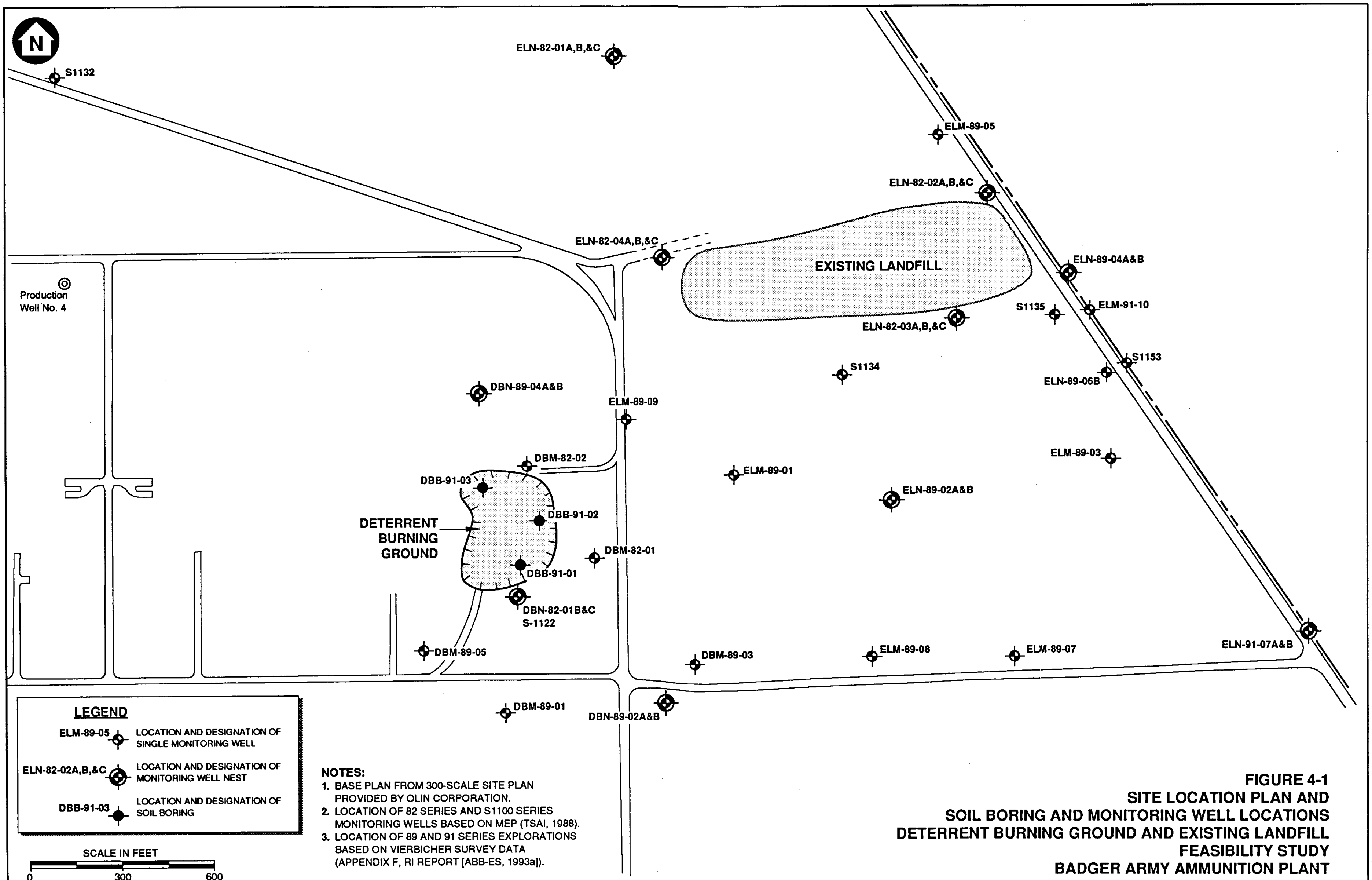
RI/FS COMPONENT	CONTAMINATED MEDIA AT DETERRENT BURNING GROUND	
	SUBSURFACE SOIL	GROUNDWATER
Identification of Contaminants of Concern	• VOCs • SVOCs • Explosives • Inorganics	• VOCs • SVOCs • Inorganics • Explosives
Risk Assessment Results	• 24DNT, 26DNT, NNDPA, and AS are a threat to humans. • 24DNT, 26DNT, AS, and CR are a potential threat to groundwater. • No ecological risk	• 26DNT, 112TCE, CR, HG, and NIT exceed MCLs or WESs. • CD, PB, and BA exceed WPALs • MN and SO4 exceed SDWA standards. • BE and NNDPA exceed interim WPALs. • No ecological risk.
Remedial Action Objectives	• Prevent concentrations of 24DNT, 26DNT, NNDPA, and AS which exceed clean-up standards for protection of human health from becoming available, either through incidental ingestion or inhalation to potential human receptors. • Prevent concentrations of 24DNT, 26DNT, AS, and CR which exceed cleanup standards for protection of groundwater from degrading groundwater quality.	• Prevent further contamination of elevated groundwater system. • Prevent exposure to concentrations of 26DNT, 112TCE, NIT, BA, CD, PB, CR, and HG exceeding their respective WPALs. • Prevent exposure of BE and NNDPA exceeding respective interim WPALs • Prevent exposure of MN and SO4 at levels exceeding SDWA levels.
Remedial Technologies Retained After Screening	• Soil Cover • Capping • Off-Site Landfill • On-site Incineration • Off-Site Incineration • Composting • Soil Washing	• Groundwater Extraction Wells • UV/Oxidation • Air Stripping • Carbon Adsorption • Resin Adsorption • UV/Reduction • Discharge to Surface Water

continued

TABLE 4-20
SUMMARY OF CONTAMINATION ASSESSMENT THROUGH REMEDIAL ALTERNATIVES SCREENING
DETERRENT BURNING GROUND

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

RI/FS COMPONENT	CONTAMINATED MEDIA AT DETERRENT BURNING GROUND	
	SUBSURFACE SOIL	GROUNDWATER
Remedial Alternatives Developed	• Minimal Action • Capping • Off-Site Landfill • Soil Washing • Off-Site Incineration • Off-Site Incineration, Soil Washing • On-Site Incineration • Composting, Soil Cover	• Minimal Action • Groundwater Extraction, IRM and Carbon Adsorption • Groundwater Extraction, IRM and UV/Oxidation-Discharge • Groundwater Extraction, IRM and Air Stripping-Carbon Adsorption, Discharge • Groundwater Extraction, IRM and Resin Adsorption, Discharge • Groundwater Extraction, IRM and UV/Reduction - Carbon Adsorption, Discharge
Remedial Alternatives Retained After Screening	• Minimal Action • Capping • Soil Washing • On-Site Incineration • Composting	• Minimal Action • Groundwater Extraction, IRM and Carbon Adsorption • Groundwater Extraction, IRM and Air Stripping, Carbon Adsorption, Discharge • Groundwater Extraction, IRM and Resin Adsorption, Discharge • Groundwater Extraction, IRM and UV/Reduction - Carbon Adsorption, Discharge

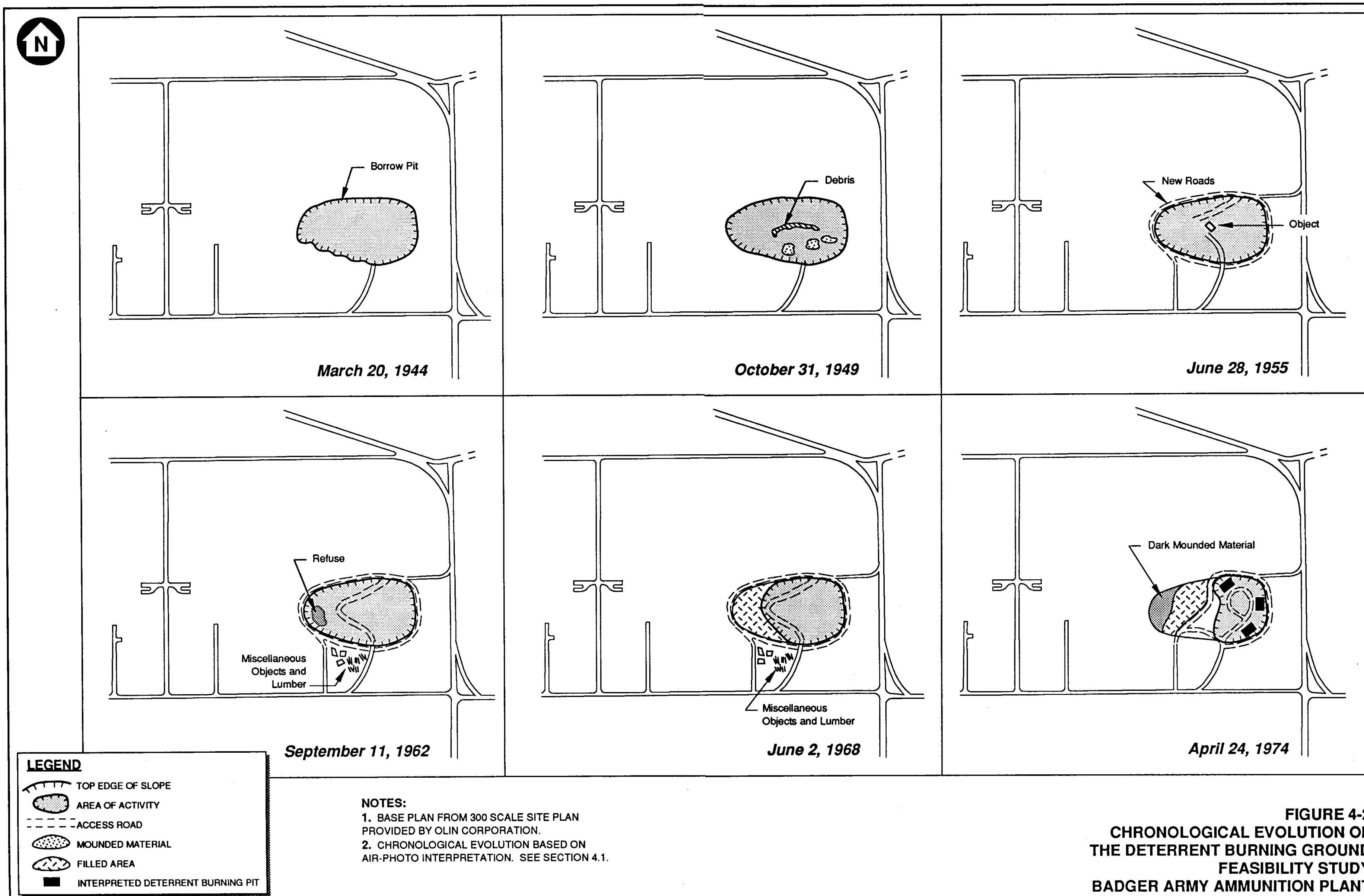


NOTES:
1. BASE PLAN FROM 300-SCALE SITE PLAN PROVIDED BY OLIN CORPORATION.
2. LOCATION OF 82 SERIES AND S1100 SERIES MONITORING WELLS BASED ON MEP (TSAI, 1988).
3. LOCATION OF 89 AND 91 SERIES EXPLORATIONS BASED ON VIERBICHER SURVEY DATA (APPENDIX F, RI REPORT [ABB-ES, 1993a]).

FIGURE 4-1
SITE LOCATION PLAN AND SOIL BORING AND MONITORING WELL LOCATIONS DETERRENT BURNING GROUND AND EXISTING LANDFILL FEASIBILITY STUDY BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407005D(j) de I

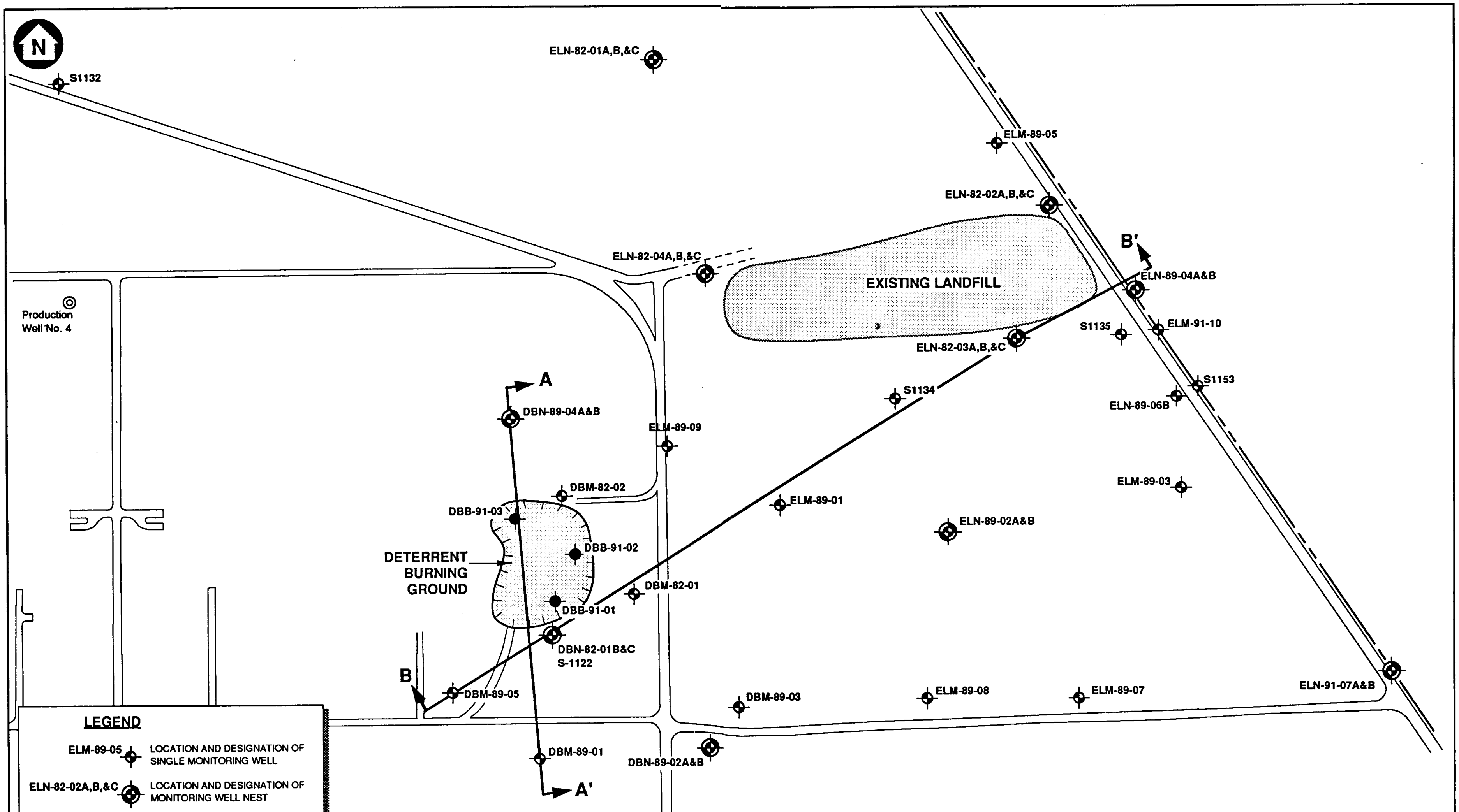


NOTES:
1. BASE PLAN FROM 300 SCALE SITE PLAN PROVIDED BY OLIN CORPORATION.
2. CHRONOLOGICAL EVOLUTION BASED ON AIR-PHOTO INTERPRETATION. SEE SECTION 4.1.

FIGURE 4-2
CHRONOLOGICAL EVOLUTION OF THE DETERRENT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9211074D



NOTES:
1. BASE PLAN FROM 300-SCALE SITE PLAN PROVIDED BY OLIN CORPORATION.
2. GEOLOGIC CROSS SECTIONS ARE PRESENTED ON FIGURES 4-4 and 4-5.

FIGURE 4-3
LOCATION AND ORIENTATION OF GEOLOGIC CROSS-SECTIONS
DETERRENT BURNING GROUND AND EXISTING LANDFILL
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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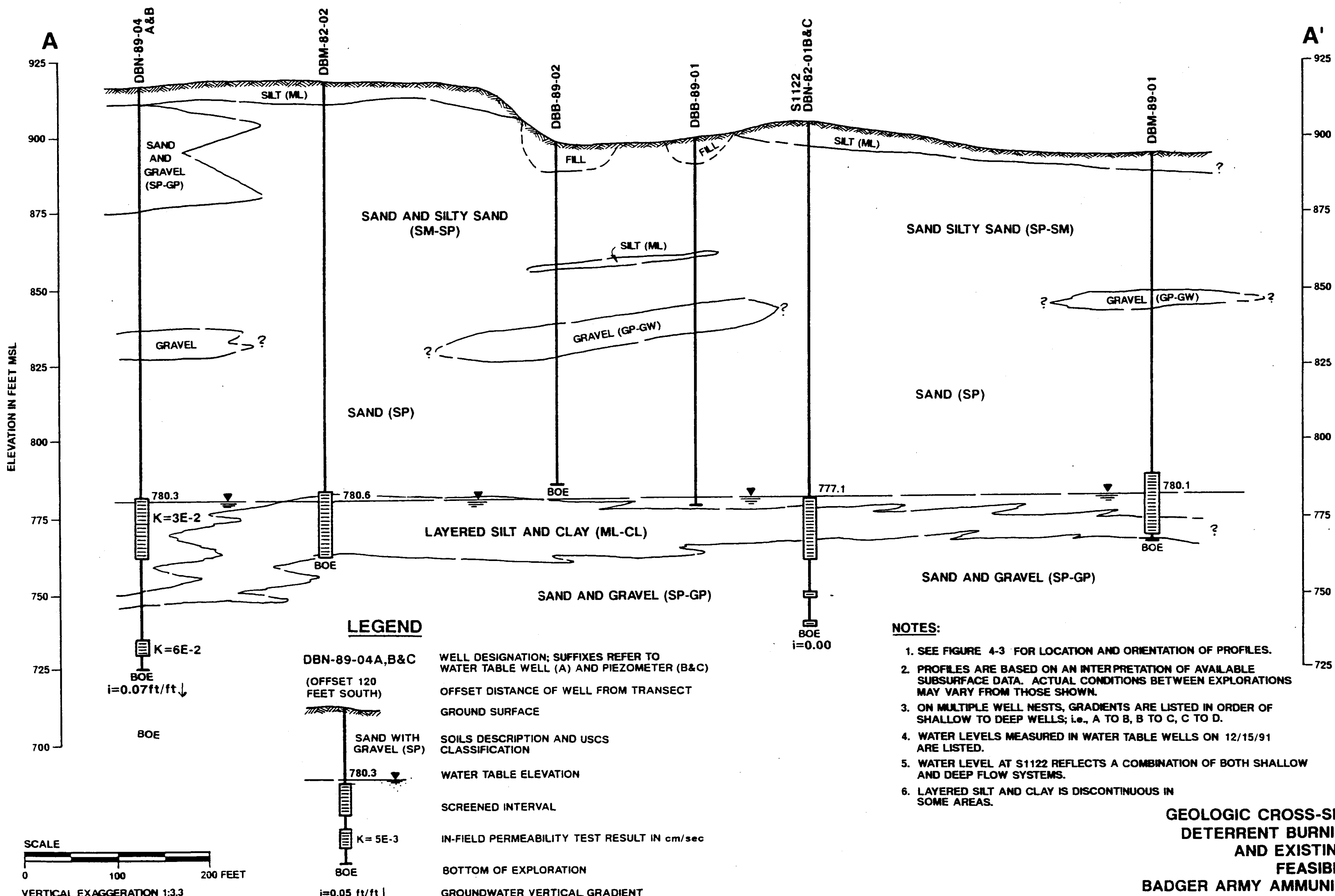


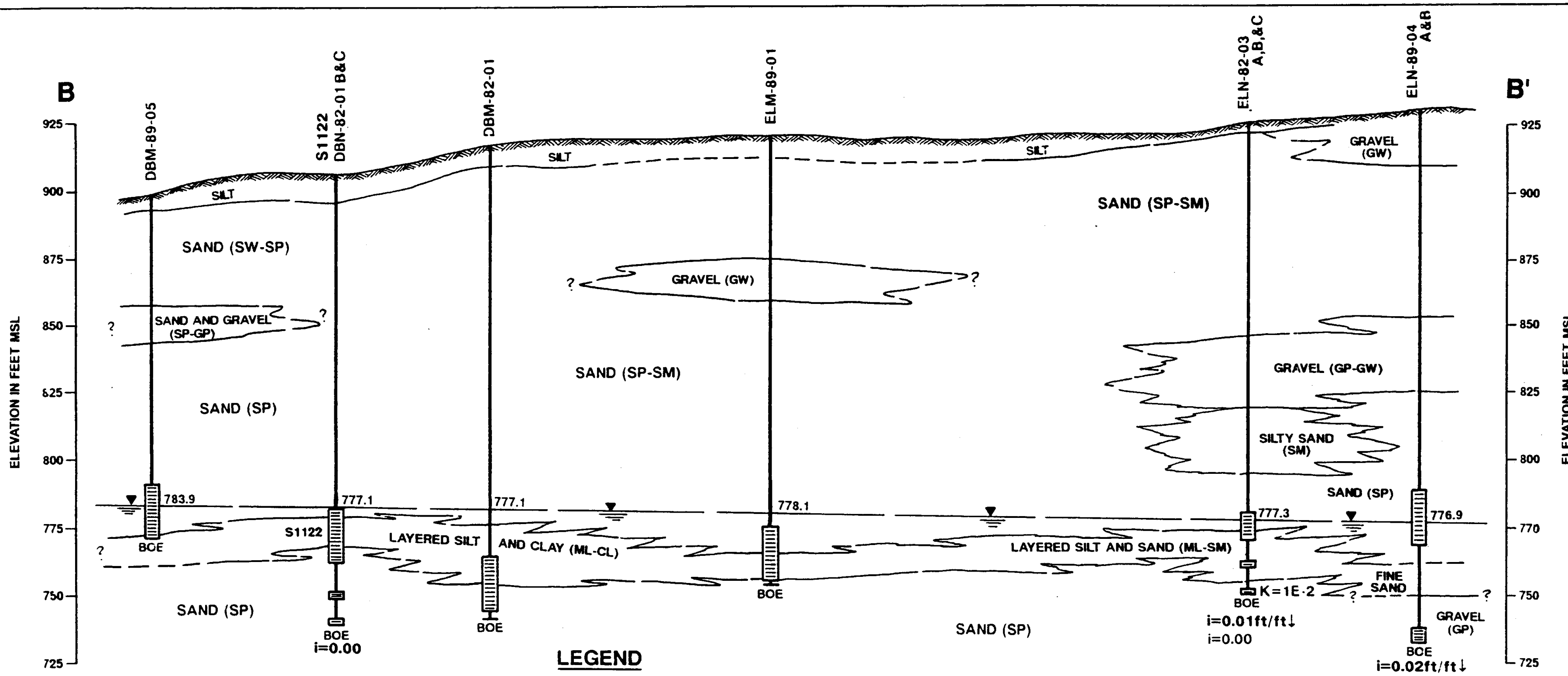
NOTES:

1. SEE FIGURE 4-3 FOR LOCATION AND ORIENTATION OF PROFILES.
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA. ACTUAL CONDITIONS BETWEEN EXPLORATIONS MAY VARY FROM THOSE SHOWN.
3. ON MULTIPLE WELL NESTS, GRADIENTS ARE LISTED IN ORDER OF SHALLOW TO DEEP WELLS; i.e., A TO B, B TO C, C TO D.
4. WATER LEVELS MEASURED IN WATER TABLE WELLS ON 12/15/91 ARE LISTED.
5. WATER LEVEL AT S1122 REFLECTS A COMBINATION OF BOTH SHALLOW AND DEEP FLOW SYSTEMS.
6. LAYERED SILT AND CLAY IS DISCONTINUOUS IN SOME AREAS.

FIGURE 4-4
GEOLOGIC CROSS-SECTION A-A'
DETERRENT BURNING GROUND
AND EXISTING LANDFILL
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

5753-15



LEGEND

DBN-89-04A,B&C	WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B&C)
(OFFSET 120 FEET SOUTH)	OFFSET DISTANCE OF WELL FROM TRANSECT-
	GROUND SURFACE
SAND WITH GRAVEL (SP)	SOILS DESCRIPTION AND USCS CLASSIFICATION
780.3	WATER TABLE ELFVATION
	SCREENED INTERVAL
K= 5E-3	IN-FIELD PERMEABILITY TEST RESULT IN cm/sec
BOE	BOTTOM OF EXPLORATION
i=0.05 ft/ft ↓	GROUNDWATER VERTICAL GRADIENT

NOTES

1. SEE FIGURE 4-3 FOR LOCATION AND ORIENTATION OF PROFILES.
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA. ACTUAL CONDITIONS BETWEEN EXPLORATIONS MAY VARY FROM THOSE SHOWN.
3. ON MULTIPLE WELL NESTS, GRADIENTS ARE LISTED IN ORDER OF SHALLOW TO DEEP WELLS; i.e., A TO B, B TO C, C TO D.
4. WATER LEVELS MEASURED IN WATER TABLE WELLS ON 12/15/91 ARE LISTED.
5. WATER LEVEL IN S1122 REFLECTS A COMBINATION OF BOTH SHALLOW AND DEEP FLOW SYSTEMS.
6. LAYERED SILT AND CLAY GRADES TO FINE SAND AND BECOMES DISCONTINUOUS EAST OF ELN-82-03C.

SCALE

0 200 400 FEET

VERTICAL EXAGGERATION 1:5

FIGURE 4-5
GEOLOGIC CROSS-SECTION B-B'
DETERRENT BURNING GROUND
AND EXISTING LANDFILL
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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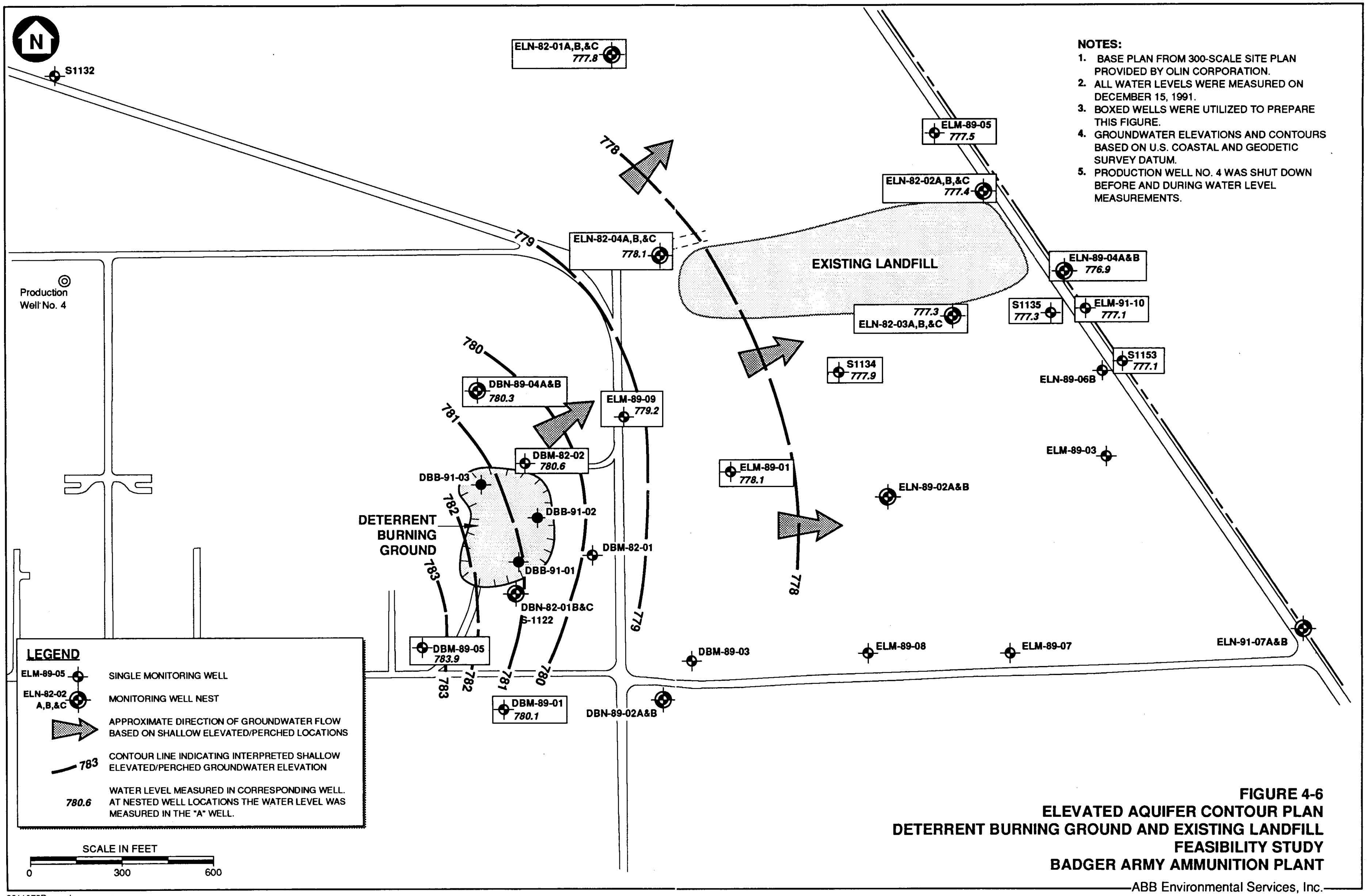

NOTES:

1. BASE PLAN FROM 300-SCALE SITE PLAN PROVIDED BY OLIN CORPORATION.
2. ALL WATER LEVELS WERE MEASURED ON DECEMBER 15, 1991.
3. BOXED WELLS WERE UTILIZED TO PREPARE THIS FIGURE.
4. GROUNDWATER ELEVATIONS AND CONTOURS BASED ON U.S. COASTAL AND GEODETIC SURVEY DATUM.
5. PRODUCTION WELL NO. 4 WAS SHUT DOWN BEFORE AND DURING WATER LEVEL MEASUREMENTS.

FIGURE 4-6
ELEVATED AQUIFER CONTOUR PLAN
DETERRENT BURNING GROUND AND EXISTING LANDFILL
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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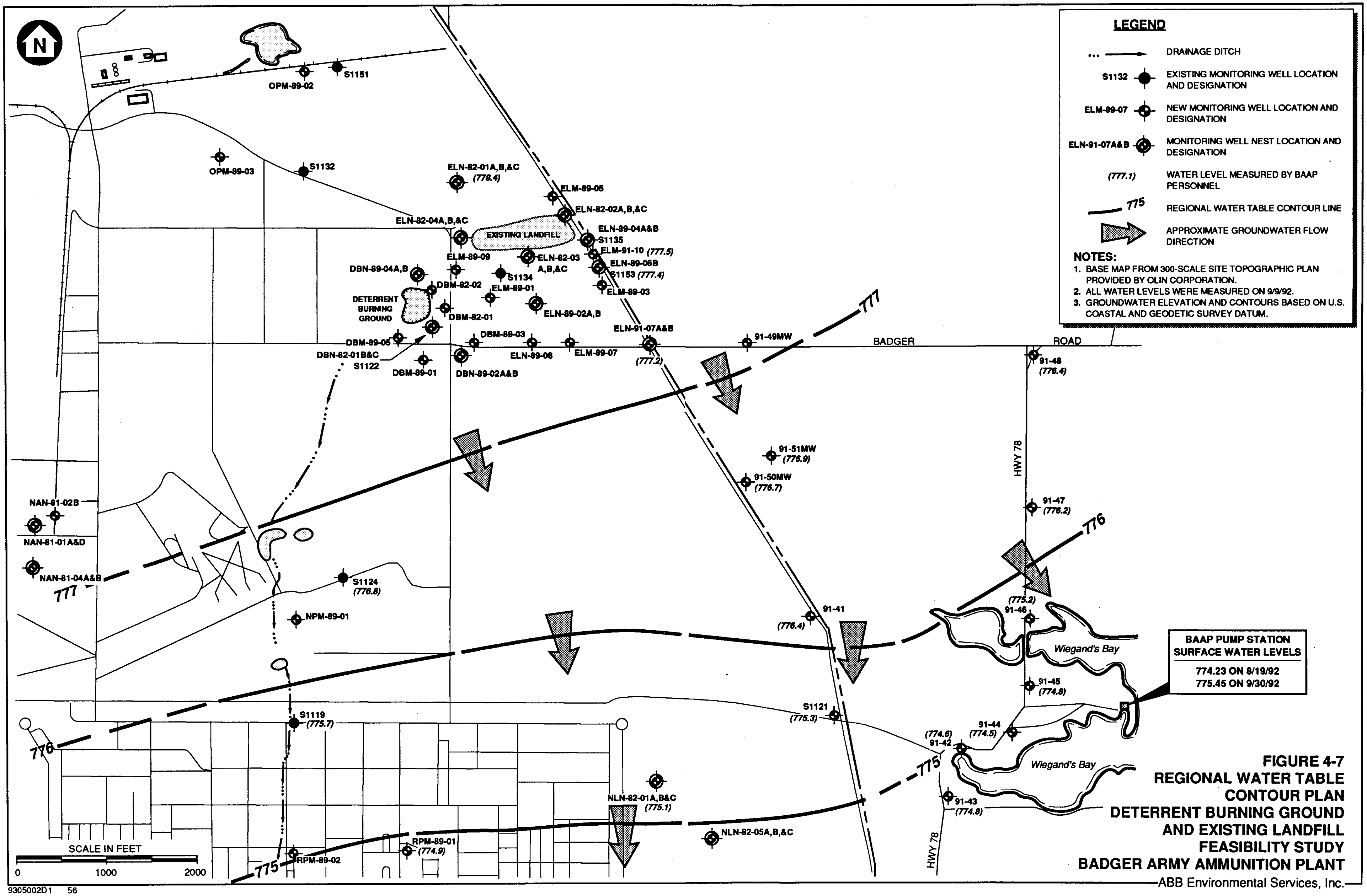
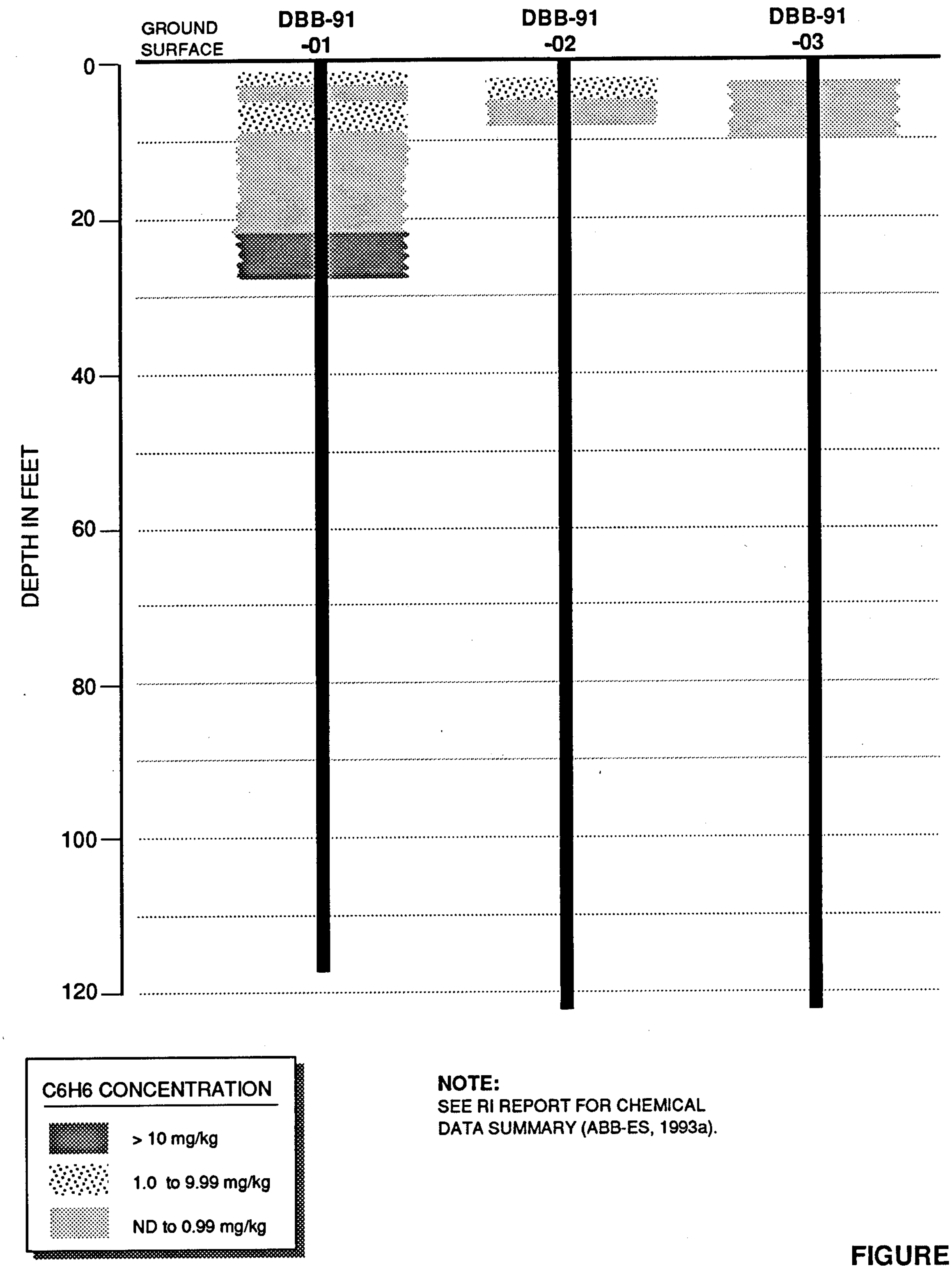


FIGURE 4-7
REGIONAL WATER TABLE CONTOUR PLAN
DETERRENT BURNING GROUND AND EXISTING LANDFILL
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

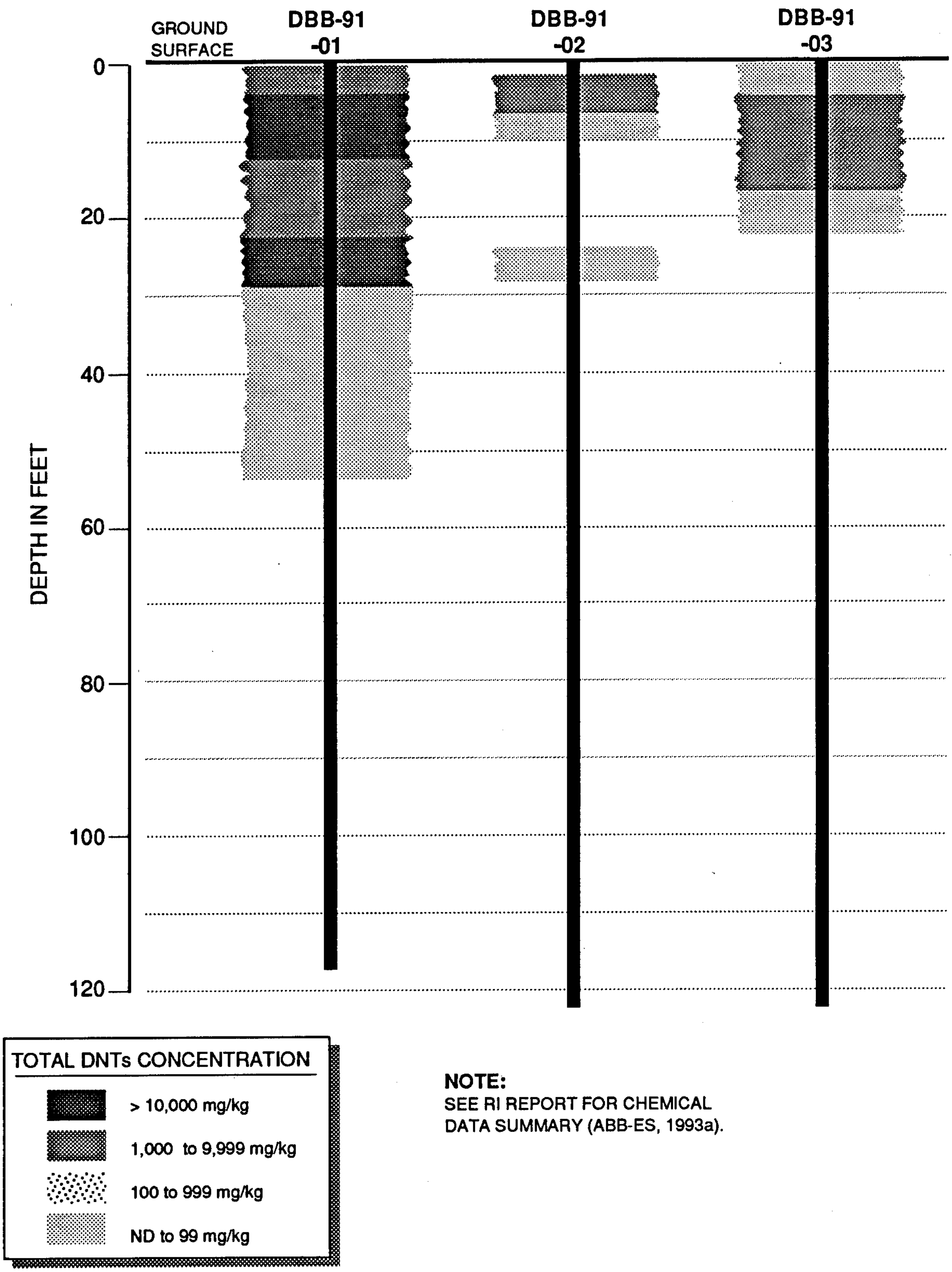


NOTE:
SEE RI REPORT FOR CHEMICAL DATA SUMMARY (ABB-ES, 1993a).

FIGURE 4-8
TOTAL C6H6 CONCENTRATIONS IN SUBSURFACE SOILS
DETERRENT BURNING GROUND WASTE PITS
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407005D(k) 1

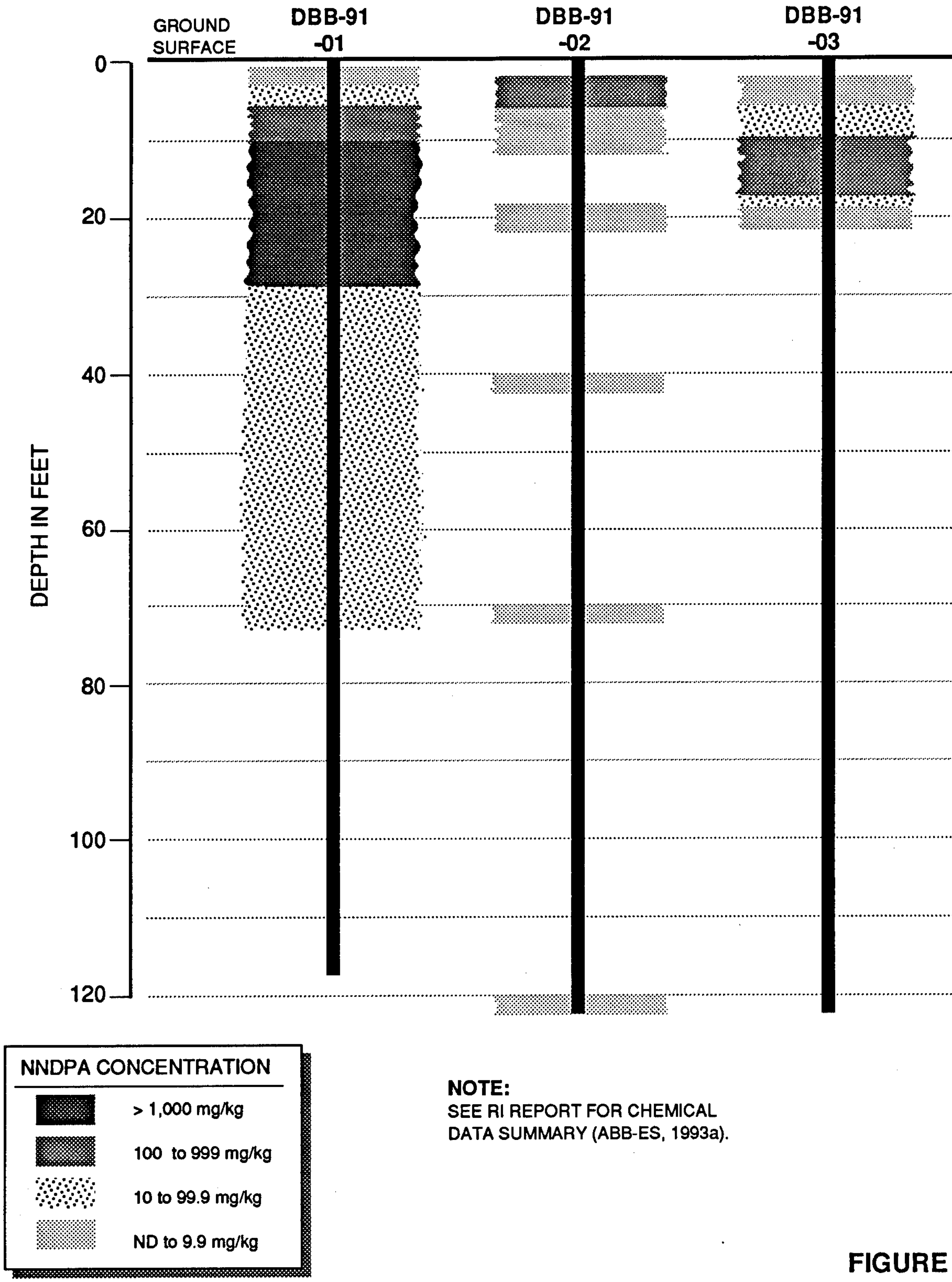


NOTE:
SEE RI REPORT FOR CHEMICAL DATA SUMMARY (ABB-ES, 1993a).

FIGURE 4-9
TOTAL DNTs CONCENTRATION IN SUBSURFACE SOILS
DETERRENT BURNING GROUND WASTE PITS
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407005D(k) 2



NOTE:
SEE RI REPORT FOR CHEMICAL DATA SUMMARY (ABB-ES, 1993a).

FIGURE 4-10
NNDPA CONCENTRATIONS IN SUBSURFACE SOILS
DETERRENT BURNING GROUND WASTE PITS
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407005D(k) 3

TABLE 5-1
SUMMARY OF FREQUENCY AND MAXIMUM DETECTED CONCENTRATIONS
SURFACE SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

	SURFACE SOIL								SEDIMENT			
	NG POND		RP POND		W. RPA		E. RPA		NG POND		RP POND	
COMPOUND	FREQUENCY OF 2 SAMPLES	MAX. CONC. (µg/g)	FREQUENCY OF 2 SAMPLES	MAX. CONC. (µg/g)	FREQUENCY OF 26 SAMPLES	MAX. CONC. (µg/g)	FREQUENCY OF 38 SAMPLES	MAX. CONC. (µg/g)	FREQUENCY OF 8 SAMPLES	MAX. CONC. (µg/g)	FREQUENCY OF 2 SAMPLES	MAX. CONC. (µg/g)
<u>SVOCs</u>												
123PDA	NA	-	0	-	1	19.000S	0	-	NA	-	0	-
24DNT	NA	-	0	-	0	-	12	810.000	NA	-	0	-
26DNT	NA	-	0	-	0	-	10	32.500	NA	-	0	-
B2EHP	NA	-	0	-	1	1.610	1	1.560	NA	-	0	-
BAANTR	NA	-	0	-	1	0.173	3	0.666	NA	-	0	-
BBFANT	NA	-	0	-	0	-	2	2.130	NA	-	0	-
BGHIPY	NA	-	0	-	0	-	1	1.910	NA	-	0	-
CHRY	NA	-	0	-	3	0.189	5	1.00	NA	-	0	-
DEP	NA	-	0	-	19	49.800	14	6.200 GT	NA	-	1	2.460
FANT	NA	-	0	-	9	0.179	11	1.120	NA	-	0	-
NG	2	15.800	0	-	19	48.500	23	1500.000	0	-	1	1.760
NNDMEA	NA	-	0	-	1	0.040	6	0.302	NA	-	0	-
NNDNPA	NA	-	0	-	0	-	5	0.230	NA	-	0	-
NNDPA	NA	-	0	-	22	81.000	36	10,000.000	NA	-	2	4.980
PHANTR	NA	-	0	-	7	0.129	7	0.279	NA	-	0	-
PYR	NA	-	0	-	3	0.223	5	0.932	NA	-	0	-

continued

TABLE 5-1
SUMMARY OF FREQUENCY AND MAXIMUM DETECTED CONCENTRATIONS
SURFACE SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

	Surface Soil								Sediment			
	NG Pond		RP Pond		W. RPA		E. RPA		NG Pond		RP Pond	
Compound	Frequency of 2 Samples	Max. Conc. (µg/g)	Frequency of 2 Samples	Max. Conc. (µg/g)	Frequency of 26 Samples	Max. Conc. (µg/g)	Frequency of 38 Samples	Max. Conc. (µg/g)	Frequency of 8 Samples	Max. Conc. (µg/g)	Frequency of 2 Samples	Max. Conc. (µg/g)
Metals												
CR	2	39.500	2	17.400	26	66.500	38	109.000	8	40.500	2	45.700
HG	1	2.400	0	-	2	0.069	15	0.716	8	. 20.000	2	0.157
PB	2	10,000.000	2	3500.00	26	1400.00	38	2,200.000	8	410.000	2	2,600.000
Anions												
NIT	NA	-	2	4.150	2.5	8.540	38	120.00	NA	-	2	2.220
SO4	NA	-	2	10.200	7	17.100	8	22.900	NA	-	2	210.00
Indicator Parameter												
NH3	2	17.700	NA	-	NA	-	NA	-	8	72.500	NA	-

Notes:

RPA = Rocket Paste Area
S = results based on internal standards
SVOCs = Semivolatile Organic Compounds
NA = Not analyzed
GT = Greater than the reported value
µg/g = micrograms per gram; equivalent to parts per million (ppm)

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

TABLE 5-2
SUMMARY OF CHEMICAL DATA
SURFACE WATER
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	ROCKET PASTE POND		NITROGLYCERINE POND	
	RPW-91-01 (µg/L)	RPW-91-02 (µg/L)	NPW-91-01 (µg/L)	NPW-91-02 (µg/L)
SVOCs				
N2KJEL	2,600	3,800	1,800	3,100
NH3N2	33.8	63.4	63.4	147
Metals				
AL	5,410	31,400	3,020	2,140
AS	8.6	15.0	5.43	4.98
BA	121	290	47.3	63.1
BE	-	2.17	-	-
CA	30,800	38,200	11,700	15,200
CR	-	59.5	-	-
CU	21.3	79.1	-	-
FE	7,980	31,700	3,970	2,920
HG	-	-	0.325	0.324
K	43,000	44,000	12,800	15,000
MG	14,900	20,900	5,340	5,880
MN	152	503	81.7	207
NA	1,190	2,000	7,790	8,320
PB	910	3,100	41.2	45.9
V	22.3	57.1	8.37	6.62
ZN	34.9	151	-	-

Notes:

µg/L = micrograms per liter

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

TABLE 5-3
HUMAN HEALTH CHEMICALS OF CONCERN
NITROGLYCERINE POND

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

CHEMICAL OF CONCERN	EXPOSURE POINT CONCENTRATION[1]		
	SURFACE SOIL (µg/g)	POND SEDIMENT (µg/g)	SURFACE WATER (mg/L)
AL	--	--	3.02
AS	--	--	0.00543
BA	--	--	0.0631
CL	--	--	1.93
CR	39.5	40.5	--
HG	2.40	20.0	0.000325
MN	--	--	0.207
NG	15.8	--	--
NH3	17.7	72.5	--
NH3N2	--	--	0.147
PB	10,000	410	0.0459
SO4	--	--	4.47
V	--	--	0.00837

Notes:

-- = Not identified as a compound of concern
[1] Exposure point concentration is the maximum detected concentration
µg/g = micrograms per gram; equivalent to parts per million (ppm)
mg/L = milligram per liter

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

TABLE 5-4
HUMAN HEALTH CHEMICALS OF CONCERN
ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

CHEMICAL OF CONCERN	EXPOSURE POINT CONCENTRATION[1]		
	SURFACE SOIL (μg/g)	POND SEDIMENT (μg/g)	SURFACE WATER (mg/L)
24DNT	810	--	--
26DNT	32.5	--	--
BAANTR	0.666	--	--
BBFANT	2.13	--	--
BGHIPY	1.91	--	--
CHRY	1	--	--
DEP	49.8	2.46	--
FANT	1.12	--	--
NG	1,500	1.76	--
NNDMEA	0.302	--	--
NNDNPA	0.23	--	--
NNDPA	10,000	4.98	--
PHANTR	0.279	--	--
PYR	0.932	--	--
AL	--	--	3.14
AS	--	--	0.015
BA	--	--	0.29
BE	--	--	0.00219
CL	--	--	2.73
CR	109	45.7	0.0595
CU	--	--	0.0791
HG	0.716	0.157	--
MN	--	--	0.503
NH3N2	--	--	0.0634
NI	--	--	0.0407
NIT	120	2.22	0.0105
PB	3,500	2,600	3.1
SO4	22.9	210	35
V	--	--	0.0571
ZN	--	--	0.151

Notes:

-- = Not identified as a compound of concern
[1] Exposure point concentration is the maximum detected concentration
μg/g = micrograms per gram; equivalent to parts per million (ppm)
mg/L = milligrams per liter

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

TABLE 5-5
CLEAN-UP STANDARDS
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	SURFACE SOIL		SEDIMENTS	
	PROTECTION OF GROUNDWATER[1] (mg/kg)	PROTECTION OF HUMAN HEALTH[2] (mg/kg)	PROTECTION OF GROUNDWATER[1] (mg/kg)	PROTECTION OF HUMAN HEALTH[2] (mg/kg)
Organics				
24DNT	9.253	4.29		
26DNT	242.144	4.29		
CPAH[3]	NPAL	0.40	-	-
BGHIPY	-	41720	-	-
DEP	NPAL	834,400	NPAL	834,400
FANT	NPAL	41,720	-	-
NG	NPAL	NHD	NPAL	NHD
NNDMEA	NPAL	0.06	NPAL	-
NNDNPA	NPAL	NHD	NPAL	-
NNDPA	NI	595.92	NI	595.92
PHANTR	NPAL	41,720	-	-
PYR	NPAL	31,290	-	-
Metals				
CR	2.517	211.95	9.82	211.95
HG	NLD	312.5	-	312.5
PB	3.854	500	15.03	500

Notes:

NPAL = No Wisconsin Preventive Action Limit (unable to calculate soil concentration that is protective of groundwater).
NHD = No human toxicity data.
NI = No impact on groundwater.
NLD = No leaching data for modeling.
mg/kg = milligrams per kilogram.
\- = Not a human health contaminant of concern.
[1]Protective of groundwater per the proposed Chapter NR 720.
[2]Protective of human health per the proposed Chapter NR 720.
[3]Carcinogenic PAHs; consisting of BAANTR, BBFANT, and CHRY in surface soil.

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

Table 5-6
Groundwater Summary
Nitroglycerine Pond and Rocket Paste Area

Feasibility Study
Badger Army Ammunition Plant

Compound of Potential Concern	Frequency of Detection	Maximum Detected Concentration (μg/L)	Minimum Detected Concentration (μg/L)	SDWA (1)		WI Groundwater Standards (2)		Calculated Concentration (3) (μg/L)
				MCL (μg/L)	MCLG (μg/L)	ES (μg/L)	PAL (μg/L)	
BA	6:6	110	24.4	2,000	2,000	2,000	400	-
CD	2:42	3.41	3.29	5	5	5	0.5	-
CHCL3	5:42	1.51	0.543	-	-	6	0.6	-
CL	48:48	89,000	3,200	250,000(a)	-	250,000	125,000	-
CR	19:42	11.9	4.71	100	100	100	10	-
CU	4:10	17.4	4.69	TT	1,300	1,300	130	-
NA	16:18	99,000	2,350	20,000(b)	-	-	-	-
NIT	48:48	11,000	810	10,000	10,000	10,000	2,000	-
PB	4:42	17	7.46	TT	0	15	1.5	-
SO4	48:48	150,000	10,000	250,000(a)	-	-	-	-
TRCLE	1:42	0.531	-	5	0	5	0.5	-

continued

TABLE 5-6
GROUNDWATER SUMMARY
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND OF POTENTIAL CONCERN	FREQUENCY OF DETECTION	MAXIMUM DETECTED CONCENTRATION (µg/L)	MINIMUM DETECTED CONCENTRATION (µg/L)	SDWA (1)		WI GROUNDWATER STANDARDS (2)		CALCULATED CONCENTRATION (3) (µg/L)
				MCL (µg/L)	MCLG (µg/L)	ES (µg/L)	PAL (µg/L)	
V	5:6	17.8	5.25	-	-	-	-	260
ZN	4:10	197	26.1	5,000(a)	-	5,000	2,500	7,300

Sources:

(1) U.S. Environmental Protection Agency (USEPA), 1991, "Fact Sheet: National Primary Drinking Water Standards." Office of Water, Washington, D.C., August 1991; USEPA, 1991, "Fact Sheet: National Secondary Drinking Water Standards," Office of Water, Washington, D.C., September 1991; and USEPA, 1990, "National Primary and Secondary Drinking Water Regulations; Synthetic Organic Chemicals and Inorganic Chemicals, Final Rule," 57FR31776, July 17, 1992 (see Subsection 3.6 for details).
(2) Wisconsin Administrative Code, Chapter NR 140.10, Table 1 (see Subsection 3.6 for details).
(3) Calculated to be protective at risk of 10^{-6} or HI of 1 (see Subsection 4.5 for details).

Notes:

(a) Secondary drinking water standard, suggested level.
(b) Reporting level. Monitoring is required and data is reported to health officials to protect individuals on restricted sodium diet.
µg/L = milligrams per liter
SDWA = Safe Drinking Water Act
MCL = Maximum Contaminant Level
MCLG = Maximum Contaminant Level Goal
WI = Wisconsin
ES = Enforcement Standard
PAL = Preventive Action Limit
TT = Treatment technique requirement in effect
Copper action level = 0.0013 µg/L, Lead action level = 0.015 µg/L

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

TABLE 5-7
ECOLOGICAL CONTAMINANTS OF CONCERN
NITROGLYCERINE POND

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	FREQUENCY	EXPOSURE POINT CONCENTRATION[A]
Surface Soil		
HG	1:2	2.4
NG	2:2	15.8
NH3	2:2	17.7
PB	2:2	10,000
Surface Water		
AL	2:2	3,020
AS	2:2	5.43
BA	2:2	63.1
CL	2:2	1,930
FE	2:2	3,970
HG	2:2	0.325
MN	2:2	207
NH3N2	2:2	147
PB	2:2	45.9
SO4	2:2	4,470
V	2:2	8.37
Sediment		
CR	8:8	40.5
HG	8:8	20
NH3	8:8	72.5
PB	8:8	410

Notes:

[A] 95th percentile or maximum; units in $\mu g/g$ (surface soil and sediment) and $\mu g/L$ (surface water).

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

TABLE 5-8[A]
ECOLOGICAL CONTAMINANTS OF CONCERN
ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	FREQUENCY	EXPOSURE POINT CONCENTRATION[B]
Surface Soil[C]		
24DNT	12:72	810
26DNT	10:72	32.5
BAANTR	4:72	0.666
CHRY	8:72	1
CR	66:66	109
DEP	37:72	49.8
FANT	20:72	1.12
HG	17:66	0.716
NG	42:66	1,500
NIT	65:66	120
NNDMEA	7:22	0.302
NNDNPA	5:72	0.23
NNDPA	58:72	10,000
PB	66:66	3,500
PHANTR	14:72	0.279
PYR	8:72	0.932
SO4	17:66	22.9
Surface Water[D]		
AL	2:2	31,400
AS	2:2	15
BA	2:2	290
BE	1:2	2.17
CL	2:2	2,730
CR	1:2	59.5
CU	2:2	79.1
FE	2:2	31,700
MN	2:2	503

continued

TABLE 5-8[A]
ECOLOGICAL CONTAMINANTS OF CONCERN
ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	FREQUENCY	EXPOSURE POINT CONCENTRATION[B]
NH3N2	2:2	63.4
NI	1:2	40.7
NIT	1:2	10.5
PB	2:2	3,100
SO4	2:2	35,000
V	2:2	57.1
ZN	2:2	151
Sediment[E]		
CR	2	45.7
DEP	1	2.46
NG	1	1.76
NIT	2	2.22
NNDPA	2	4.98
PB	2	2,500
SO4	2	210

Notes:

[A] Constituents selected based on criteria presented in Tables Q-16 and Q-17 and discussed in Section 5.0 of the Final RI Report (ABB-ES, 1993a).
[B] 95th percentile or maximum; units in $\mu g/g$ (surface soil) and $\mu g/\ell$ (surface water).
[C] Assessment of surface soil contamination (0 to 2 feet) was performed using samples from RPS-91-03 through RPS-91-68.
[D] Assessment of surface water contamination was performed using samples from RPW-91-01 and RPW-91-02.
[E] Assessment of sediment contamination was performed using samples from RPS-91-01 and RPS-91-02.

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

TABLE 5-9
SUMMARY OF RISK EVALUATION FOR AQUATIC RECEPTORS
NITROGLYCERINE POND

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	EXPOSURE POINT CONCENTRATION[A]	RTV[B]	HAZARD QUOTIENT[C]
Surface Water[D]			
AL	3,020	248	4
AS	5.43	153	0.035
BA	63.1	1,360	0.046
CL	1,930	230,000	0.02
FE	31,700	1,000	31.7
HG	0.325	0.012	27
MN	207	100	2.1
NH3N2	147	2,100	0.07
PB	45.9	3.2	14
SO4	4,470	1,060,000	0.0042
V	8.37	200	0.042
Sediments[E]			
CR	40.5	100	0.41
HG	20	0.1	200
NH3	72.5	75	0.97
PB	410	50	8.2

Notes:

[A] Analytical results presented in Tables Q-19 and Q-20 and summarized in Table 8-18 of the Final RI Report (ABB-ES, 1993a).

[B] Reference Toxicity Value (RTV) derived from available quality criteria and effects threshold levels as presented in Table Q-3 of the Final RI Report (ABB-ES, 1993a).

[C] Calculated by dividing the exposure point concentration by the RTV; values in excess of 1.0E+00 indicate that the protective RTV was exceeded by environmental concentrations.

[D] Units are $\mu g/L$.

[E] Units are $\mu g/g$.

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

TABLE 5-10
SUMMARY OF RISK EVALUATION FOR TERRESTRIAL RECEPTORS
NITROGLYCERINE POND

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

	HAZARD INDICES[A]	
RECEPTOR	ACUTE RISK[B]	CHRONIC RISK[C]
Short-tailed shrew	1.9E+04	3.8E+05
Eastern meadowlark	4.3E+02	4.8E+02
Garter snake	9.3E+02	7.4E+03
Red fox	1.7E+01	1.3E+00
Red-tailed hawk	5.0E+01	2.3E+00

Notes:

[A] Sum of the individual Hazard Quotients for each surface soil contaminant of concern; each HQ calculated by dividing the estimated exposure dosage by the Reference Toxicity Value (RTV).

[B] Based on comparison with acute RTVs.

[C] Based on comparison with chronic RTVs.

TABLE 5-11
SUMMARY OF RISK EVALUATION FOR AQUATIC RECEPTORS
ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	EXPOSURE POINT CONCENTRATION[A]	RTV[B]	HAZARD QUOTIENT[C]
Surface Water			
AL	31,400	748	41.9
AS	15	153	0.098
BA	290	1,360	0.21
BE	2.17	5.3	0.41
CL	2,730	230,000	0.029
CR	59.5	9.74	6.1
CU	79.1	2.27	35
FE	31,700	1,000	32
MN	503	100	5
NH3N2	63.4	2,100	0.03
NI	40.7	66.13	0.62
NIT	10.5	5,000	0.0021
PB	3,100	3.2	970
SO4	35,000	1,060,000	0.033
V	57.1	200	0.29
ZN	151	49.59	3
Sediment			
CR	45.7	100	.46
NIT	2.22	54.5	.004
PB	2,600	50	52
SO4	210	-	-
DEP	2.46	-	-
NNDPA	4.98	-	-
NG	1.75	-	-

Notes:

[A] Analytical results presented in Tables Q-17 and summarized in Table 8-19 of the Final RI Report (ABB-ES, 1993a).
[B] Reference Toxicity Value (RTV) derived from available quality criteria and effects threshold levels as presented in Table Q-3 of the Final RI Report (ABB-ES, 1993a).
[C] Calculated by dividing the exposure point concentration by the RTV; values in excess of 1.0E+00 indicate that the protective RTV was exceeded by environmental concentrations.

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

Table 5-12
Summary of Risk Evaluation for Terrestrial Receptors
Rocket Paste Area

Feasibility Study
Badger Army Ammunition Plant

	Hazard Indices[A]	
Receptor	**Acute Risk[B]**	**Chronic Risk[C]**
Short-tailed shrew	6.6E+03	1.3E+05
Eastern meadowlark	1.5E+02	4.4E+02
Garter snake	3.3E+02	6.5E+03
Red fox	1.9E+01	1.4E+02
Red-tailed hawk	2.9E+01	3.0E+02

Notes:

[A] Sum of the individual Hazard Quotients for each surface soil contaminant of concern; each HQ calculated by dividing the estimated exposure dosage by the Reference Toxicity Value (RTV).

[B] Based on comparison with acute RTVs.

[C] Based on comparison with chronic RTVs.

TABLE 5-13
REMEDIATION GOALS
SURFACE SOIL, SEDIMENT, AND SURFACE WATER
NITROGLYCERINE POND

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

MEDIA	COMPOUND	MAXIMUM CONCENTRATION DETECTED	MAXIMUM BACKGROUND CONCENTRATION[1]	ACCEPTABLE ARAR-BASED CONCENTRATION[2]	ACCEPTABLE RISK-BASED CONCENTRATION[3]	ACCEPTABLE NR 720 BASED CONC. FOR GROUNDWATER[4]	ACCEPTABLE NR 720 BASED CONC. FOR HUMAN HEALTH[5]	REMEDIATION GOAL	RATIONALE
Surface Soil (mg/kg)	PB	10,000	30	1,000	0.0089	3.854	500	30	Background
	HG	2.4	0.38	-	0.05	NLD	312.5	0.38	Background
	NG	15.8	-	-	3.6	NPAL	-	3.6	Ecological Risk
Sediment (mg/kg)	CR	40.5	159	NA	22	9.82	211.95	159	Background
	HG	20	0.38	NA	0.1		312.5	0.38	Background
	PB	410	201[6]	NA	23	15.03	500	201	Background
Surface Water (µg/L)	AL	3,020	NA	NA	748	NA	NA	748	Ecological Risk
	FE	3,970	NA	NA	1,000	NA	NA	1,000	Ecological Risk
	HG	0.325	NA	NA	0.012	NA	NA	0.012	Ecological Risk
	MN	207	NA	NA	50	NA	NA	50	Ecological Risk
	PB	45.9	NA	NA	3.2	NA	NA	3.2	Ecological Risk

Notes:

1 Maximum background concentrations are the high end of the range of either the BAAP or the regional background concentration presented in the Final RI Report, whichever is greatest (ABB-ES, 1993a).
2 Only compound with ARAR-based concentration is PB. ARAR for PB is Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites. OSWER Directive #9355.4-02, September 1989.
3 Acceptable risk-based concentration is result of ecological risk evaluation for terrestrial receptors.
4 Acceptable concentration based on protection of groundwater from proposed Chapter NR 720.
5 Acceptable concentration based on protection of human health from proposed Chapter NR 720.
6 Background soil concentration was used because background sediment concentrations are not available.

NA = Not applicable
NPAL = No Wisconsin Preventive Action Limit (unable to calculate soil concentration that is protective of groundwater.
NLD = No leaching data for modeling
\- = Not a human health contaminant of concern
mg/kg = milligrams per kilogram
µg/L = micrograms per liter

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

Table 5-14
Remediation Goals
Surface Soil, Sediment, and Surface Water
Rocket Paste Area

Feasibility Study
Badger Army Ammunitions Plant

Media	Compound	Maximum Concentration Detected	Maximum Background Concentration[1]	Acceptable ARAR-Based Concentration[2]	Acceptable Risk-Based Concentration[3]	Acceptable NR 720 Based Conc. for Groundwater[4]	Acceptable NR 720 Based Conc. for Human Health[5]	Remediation Goal	Rationale
Surface Soil (mg/kg)	24DNT	810	-	-	4.3	9.253	4.29	4.29	Human Health
	26DNT	32.5	-	-	4.3	242.144	4.29	4.29	Human Health
	CPAH	3.80	-	-	NR	NPAL	0.40	0.40	Human Health
	NNDPA	10,000	-	-	5.4	NI	595.92	5.4	Ecological Risk
	PB	3,500	30	1,000	0.0053	3.854	500	30	Background
	CR	109	100	-	11	2.517	211.95	100	Background
	HG	0.7	0.38	-	0.03		312.5	0.38	Background
	NG	1,500	-	-	3.6	NPAL	NHD	3.6	Ecological Risk
Sediment (mg/kg)	PB	2,600	201[6]	1,000	23	15.03	500	201	Background
Surface Water (μg/L)	AL	31,400	NA	NA	748	NA	NA	748	Ecological Risk
	CR	59.5	NA	NA	11	NA	NA	11	Ecological Risk
	CU	79.1	NA	NA	12	NA	NA	12	Ecological Risk
	FE	31,700	NA	NA	1,000	NA	NA	1,000	Ecological Risk
	MN	503	NA	NA	50	NA	NA	50	Ecological Risk
	PB	3,100	NA	NA	3.2	NA	NA	3.2	Ecological Risk
	ZN	151	NA	NA	110	NA	NA	110	Ecological Risk

Notes:

[1] Maximum background concentrations are the high end of the range of either the BAAP or the regional background concentration presented in the Final RI Report, whichever is greatest (ABB-ES, 1993a).
[2] Only compound with ARAR-based concentration is PB. ARAR for PB is Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites. OSWER Directive #9355.4-02, September 1989.
[3] Acceptable risk-based concentration is result of ecological risk evaluation for terrestrial receptors.
[4] Acceptable concentration based on protection of groundwater standards from proposed Chapter NR 720.
[5] Acceptable concentration based on protection of human health from proposed Chapter NR 720.
[6] Background soil concentration was used because background soil concentrations are not available.

NLD = No leaching data for modeling
NPAL = No Wisconsin Preventive Action Limit (unable to calculate soil concentration that is protective of groundwater)
NR = Negligible risk
NI = No impact on groundwater
mg/kg = milligrams per kilogram
μg/L = micrograms per liter

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

TABLE 5-15
GENERAL RESPONSE ACTIONS AND POTENTIAL REMEDIAL TECHNOLOGIES
SURFACE SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GENERAL RESPONSE ACTION	SOIL TECHNOLOGY	DESCRIPTION
No Action	None	No action. Site monitoring.
Minimal Action	Institutional Controls/ Education Programs/ Site Fencing	Zoning and deed restrictions are put in place on potentially contaminated areas. The public is educated concerning site hazards. A physical barrier is constructed to restrict site access.
	Soil Cover	A layer of native soil is placed over the site that is sufficiently thick to prevent direct contact and ingestion hazards associated with contaminated surface soil.
Containment	Capping (e.g. clay and soil, asphalt, clay and synthetic membrane covered with soil)	A low-permeability cover is constructed over the site to prevent direct contact and ingestion hazards associated with contact of contaminated surface soil.
Excavation/Disposal	On-Site Landfill	Soil not regulated by RCRA Land Disposal Restrictions is excavated and disposed of in a secure on-site landfill constructed for that purpose.
	Off-Site Landfill	Soil not regulated by RCRA Land Disposal Restrictions is excavated, transported and disposed of in a secure, existing off-site landfill.
	On-Site Disposal	Soil is disposed at a soil disposal area on site after appropriate treatment.
Soil Excavation/Treatment	On-Site Incineration	Soil is excavated and treated by a mobile incinerator which thermally destroys VOCs/SVOCs in a direct-fired treatment unit.
	Off-Site Incineration	Soil is excavated and transported to a licensed incinerator which thermally destroys VOCs/SVOCs in a direct-fired treatment unit.
	Solvent Extraction	Soil is excavated and mixed with a chemical solvent in a batch mixer. Soil settles out and solvent/contaminant is decanted off. The contaminant is then separated from the solvent to produce an effluent stream of concentrated contaminant.
	Stabilization/Solidification	Soil is excavated and mixed with a setting agent (e.g., cement, fly ash, lime) which entraps contaminants in a granular or monolithic product with a low leaching potential.
	Anaerobic Thermal Process	Soil is excavated and treated by a mobile unit which uses high temperatures in an anaerobic environment to desorb VOCs/SVOCs from the soil. The contaminants are condensed into a liquid waste stream.

continued

TABLE 5-15
GENERAL RESPONSE ACTIONS AND POTENTIAL REMEDIAL TECHNOLOGIES
SURFACE SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GENERAL RESPONSE ACTION	SOIL TECHNOLOGY	DESCRIPTION
Soil Excavation/ Treatment (cont.)	Soil Washing	Soil is excavated and mixed with an aqueous-based washing solution in a series of high-energy mobile washing units. VOCs/SVOCs and metals can be separated from soil with this system. Washing solution is recycled.
	Vitrification Thermal Process	Soil is excavated and treated in a reactor which heats soil to its melting point, then allows it to cool into a solid, glass-like structure. VOCs/SVOCs are either trapped in the matrix, destroyed, or volatilized.
In Situ Treatment	Stabilization/Solidification	A solidifying agent is added in place to contaminated soil to form a monolithic product in which contaminants are entrapped within a granular or monolithic product with a low leaching potential.
	Vitrification	High voltage current is passed through the contaminated zone until complete meltdown of soils has occurred. The high temperatures generated during meltdown pyrolyze and eventually combust VOCs/SVOCs constituents.
	Soil Flushing	Aqueous-based washing solution is applied at the ground surface. Contaminants are removed from soil particles and held in the liquid phase as the solution infiltrates the soil. Solution containing the contaminants is removed through extraction wells after reaching the water table.
	Bioventing	Air, nutrients, and moisture (as needed) are injected into contaminated soil to enhance the indigenous microbe environment and increase the biodegradation rate of VOCs/SVOCs.

Note:

RCRA = Resource Conservation and Recovery Act
SVOCs = Semivolatile Organic Compounds
VOCs = Volatile Organic Compounds

TABLE 5-16
REMEDIAL TECHNOLOGY SCREENING
SURFACE SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
No Action	• Easily implemented. • No costs would be incurred with this option other than for monitoring.	• Does not reduce exposure potential for human or environmental receptors or protect groundwater. • Would not reduce mobility, toxicity, or volume of contaminants.	Eliminated	Not protective of human health or the environment.
Institutional Controls/ Education Programs/ Site Fencing	• Reduces exposure potential for human and some environmental receptors. • Easily implemented. • Low potential for exposure to contaminants during implementation. • Minimal impact to environment during implementation.	• Would not reduce mobility, toxicity, or volume of contaminants. • Long-term monitoring and maintenance would be required. • Long-term liability associated with waste. • Does not achieve remedial action objectives.	Retained	Physical barriers would reduce the potential for direct contact and ingestion by human and some environmental receptors.

continued

TABLE 5-16
REMEDIAL TECHNOLOGY SCREENING
SURFACE SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Soil Cover	• Reduces exposure potential for human and environmental receptors. • Not subject to RCRA Land Disposal Restrictions. • Easily implemented.	• Would not reduce toxicity or volume of contaminants. • Would not reduce mobility of contaminants resulting from infiltration of precipitation. • Uncertain design life. • Long-term monitoring and maintenance would be required. • Long-term liability associated with waste. • Does not achieve remedial action objectives. • Soil cover would interfere with the existing drainage system.	Retained	Soil cover would reduce direct contact and ingestion hazards associated with exposure to contaminated surface soil and sediment.
Capping	• Reduces exposure potential for human and environmental receptors. • No secondary wastes produced. • Commonly used method for remediation of large contiguous areas.	• Would not reduce mobility, toxicity, or volume of contaminants. • Uncertain design life. • Long-term monitoring and maintenance would be required. • Long-term liability associated with waste. • Cap would interfere with the existing drainage system.	Eliminated	Doesn't effectively limit infiltration of precipitation in the non-contiguous Rocket Paste Area ditches.

continued

TABLE 5-16
REMEDIAL TECHNOLOGY SCREENING
SURFACE SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
On-Site Landfill	• No secondary wastes produced. • Contaminants may be relocated to a more stable, contained, lower exposure potential environment. • No transportation of waste over public roads.	• Would not reduce toxicity, or volume of contaminants. • RCRA Land Disposal Restrictions may limit wastes eligible for disposal. • Siting a landfill over an aquifer used as a drinking water source would be difficult. • Long-term monitoring and maintenance would be required. • Long-term liability associated with landfilled waste.	Eliminated	Obtaining regulatory approval of a landfill at BAAP would be difficult because of site geology (i.e., sandy soils) overlying an aquifer used as a drinking water source.
Off-Site Landfill	• Widely used and easily implemented technology. • No wastes/treatment residuals remaining on site. • Contaminants may be relocated to a more stable, contained, lower exposure potential environment. • Relatively little mobilization effort and cost. • Experienced excavation contractors available.	• Would not reduce toxicity or volume of contaminants. • RCRA Land Disposal Restrictions may limit wastes eligible for disposal. • Limited landfill capacity nationwide. • Transportation and landfilling costs may be expensive. • Long-term liability associated with landfilled wastes.	Retained	Could be used for direct disposal of soils/sediments or as an option for disposal of treatment residuals.

continued

TABLE 5-16
REMEDIAL TECHNOLOGY SCREENING
SURFACE SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
On-site Incineration	• Destruction and removal efficiencies of greater than 99.99%, thus reducing volume of contaminants. • Technology is reliable and has been demonstrated for treating VOCs/SVOCs in wastes at full scale. • Widely used for treatment of VOCs/SVOCs in wastes.	• Treatment of metals collected by air pollution control equipment may be required. • Treatment of metals remaining in soil/sediment potentially required. • Incineration of RCRA waste would require trial burns in order to receive permits to operate.	Eliminated	Not applicable for soils with high concentrations of metals because metals are not destroyed.
Off-Site Incineration	• Destruction and removal efficiencies of greater than 99.99%, thus reducing volume of contaminants. • Widely used for treatment of VOCs/SVOCs in wastes. • No long-term monitoring or maintenance required.	• Treatment of metals remaining in soil may be required. • Limited capacity at RCRA-permitted incinerators. • High cost associated with transportation and incineration of wastes.	Eliminated	Not applicable for soils with high concentrations of metals because metals are not destroyed.

continued

TABLE 5-16
REMEDIAL TECHNOLOGY SCREENING
SURFACE SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Solvent Extraction	• Capable of treating soils/ sediments contaminated with VOCs/SVOCs. • Demonstrated full-scale performance for removal of VOCs/SVOCs from sludge. • Contaminants are transferred into a manageable liquid waste stream.	• Would not reduce mobility, toxicity or volume of contaminants. • Concentrated contaminant waste stream requires further treatment. • Depending on process, residual extraction solvent may remain in soil and would require treatment. • Limited operating experience with BAAP-specific contaminated soils. • Treatability studies required. • Treatment of metals remaining in soil may be required.	Eliminated	Not proven effective for treatment of contaminated soil and would not offer any particular advantage over other proven technologies.
Stabilization/ Solidification	• Reduces mobility of metals. • Technology is reliable and has been demonstrated at full-scale for treating metals in soils/sediment. • Technology is relatively simple and easily implemented. • Experienced vendors are available.	• Would not reduce toxicity or volume of contaminants. • Volume of contaminated media potentially increased by 20-30%. • Long-term performance for treatment of VOCs/SVOCs wastes not demonstrated. • Pre-treatment for organics potentially required.	Retained	Capable of treating the metals contamination present in site surface soils and sediments.

continued

TABLE 5-16
REMEDIAL TECHNOLOGY SCREENING
SURFACE SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Anaerobic Thermal Process	• Demonstrated full-scale performance for removal of VOCs/SVOCs from soils/sediment. • Contaminants are transferred into a manageable liquid waste stream. • May not require an incinerator permit to operate.	• Would not reduce mobility, toxicity, or volume of contaminants. • Treatment of metals collected by air pollution control equipment potentially required. • Treatment of metals remaining in soil may be required. • Concentrated contaminant waste stream requires further treatment. • Limited number of transportable units available. • Treatability studies would be required.	Eliminated	Not effective for treating soils with a high metals content.

continued

TABLE 5-16
REMEDIAL TECHNOLOGY SCREENING
SURFACE SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Soil Washing	• Demonstrated at full-scale for removal of metals from soils/sediment. • Wide application to varied waste groups. • Mobile units are available.	• Potentially hazardous chemicals may be brought on site to be used in process. • Difficulty in treating complex waste mixtures. • Concentrated contaminant waste stream requires further treatment. • Potential difficulty in removing washing solution from treated soil. • Limited effectiveness for treating soils/sediment with high humic content and high fine-grained clay fraction. • Treatability studies would be required.	Eliminated	Not effective for treating surface soils/ sediment with high humic content.

continued

TABLE 5-16
REMEDIAL TECHNOLOGY SCREENING
SURFACE SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Vitrification	• Reduces mobility, toxicity, and volume of contaminants. • Effective for organics and inorganics.	• Treatment may be required to destroy VOCs/SVOCs in the vapor phase. • Vitrified soil would require disposal. • Would not be effective on soils with high moisture content. • Process is very energy intensive. • Not demonstrated at the full-scale level for hazardous wastes. • Mobile units not available. • Treatability studies would be required.	Eliminated	Technology not demonstrated at full-scale level for treatment of hazardous wastes.
In Situ Stabilization/ Solidification	• Reduces mobility of metals. • Technology has been demonstrated at pilot-scale for treating metals. • Not subject to RCRA Land Disposal Restrictions.	• Volume of contaminated media increased. • Reagent/waste ratios are difficult to control. • Not demonstrated at full-scale. • Verification of treatment can be difficult. • Treatability studies would be required.	Retained	Potentially effective for treating metals in surface soils and sediments.

continued

TABLE 5-16
REMEDIAL TECHNOLOGY SCREENING
SURFACE SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Soil Flushing	• Used in conjunction with groundwater treatment. • Effective for removal of VOCs from permeable soils. • Full-scale units are available. • Not subject to RCRA Land Disposal Restrictions.	• Difficulty in treating complex waste mixtures. • Potential for uncontrolled migration of contaminants to groundwater. • Limited effectiveness for treating soil with high humic content and high fine-grained clay fraction.	Eliminated	Should not be used where groundwater remediation is not planned. Would result in spreading contamination into a previously uncontaminated media (i.e., groundwater).
Bioventing	• Demonstrated at pilot-scale for treating hydrocarbons in soil • Reduces toxicity and volume of VOCs/SVOCs. • No secondary waste streams. • Not subject to RCRA Land Disposal Restrictions.	• Significant time and expense for laboratory degradation studies and field demonstrations. • Injected air may mobilize VOCs in the vadose zone. • Strict operating controls are required to maintain optimal biodegradation environment.	Eliminated	Not effective for treating soils/ sediments with a high metals content.

Notes:

BAAP	=	Badger Army Ammunition Plant
RCRA	=	Resource Conservation and Recovery Act
VOCs	=	volatile organic compounds
SVOCs	=	semivolatile organic compounds

TABLE 5-17
REMEDIAL TECHNOLOGIES RETAINED FOR REMEDIAL ALTERNATIVES DEVELOPMENT
SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GENERAL RESPONSE ACTION	SOIL TECHNOLOGY
Minimal Action	• Institutional Controls/Education Programs/Site Fencing
Containment	• Soil cover
Excavation/Disposal	• Off-site landfill
Excavation/Treatment	• Stabilization/Solidification • In Situ Stabilization/Solidification

TABLE 5-18
GENERAL RESPONSE ACTIONS AND POTENTIAL REMEDIAL TECHNOLOGIES
SURFACE WATER
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GENERAL RESPONSE ACTION	SURFACE WATER TECHNOLOGY	DESCRIPTION
No Action	None	No Action. May include water quality analysis to monitor contaminant levels and assess future environmental impacts.
Minimal Action	Institutional Controls/Education Programs/Site Fencing	Zoning and deed restrictions are put in place on potentially contaminated areas. The public is educated concerning site hazards. A physical barrier is constructed to restrict site access.
Treatment	Ion Exchange	Metal ions are removed from solution by exchanging ions electrostatically attached to a solid resin material for dissolved ions in solution. Regeneration of the exhausted resin would produce a concentrated waste stream requiring further treatment.
	Precipitation	Chemical precipitation involves the formation of a solid phase, usually particulate matter, suspended in a liquid phase containing the pollutant to be removed. Process generates a sludge requiring collection/treatment/ disposal.
	Adsorptive Filtration	Metals are collected by attachment to a thin layer of ferrihydrite (iron oxide) that has been immobilized on the surface of sand grains.
	Microfiltration	Metals are filtered out of the water by high-grade filters; usually used as a polishing step.
Disposal	Groundwater Reinjection	Reinject treated surface water not meeting NPDES discharge limits into groundwater on site.
	Discharge to Surface Water	Discharge of treated surface water, meeting NPDES discharge limits, into surrounding surface water.
	Return to Nitroglycerine Pond	After treatment, water would be returned to the Nitroglycerine Pond.

Note:

NPDES = National Pollutant Discharge Elimination System

TABLE 5-19
REMEDIAL TECHNOLOGY SCREENING
SURFACE WATER
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
No Action	• Easily implemented. • No costs would be incurred with this option other than for monitoring.	• Does not reduce exposure potential for human or environmental receptors. • Would not reduce mobility, toxicity, or volume of contaminants.	Eliminated	Not protective of human health or the environment.
Institutional Controls/ Education Programs/Site Fencing	• Reduces exposure potential for human and some environmental receptors. • Easily implemented. • Low potential for exposure to contaminants during implementation. • Minimal impact to environment during implementation.	• Would not reduce mobility, toxicity, or volume of contaminants. • Long-term monitoring and maintenance would be required. • Long-term liability associated with waste.	Retained	Physical barriers would reduce the potential for direct contact and ingestion by human and some environmental receptors.
Ion Exchange	• Effectively treats metals. • Demonstrated past performance. • Several experienced vendors available. • O&M costs potentially low. • Effective as a polishing step in metals treatment.	• Does not reduce the toxicity or volume of contaminants, only concentrates them. • Concentrated contaminant waste stream requires further treatment. • May require treatability investigations. • May not be able to treat to levels prescribed in the remedial goals.	Retained	Potentially effective for treating metals in the surface water.

continued

TABLE 5-19
REMEDIAL TECHNOLOGY SCREENING
SURFACE WATER
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Precipitation	• Metal concentrations can be reduced to 0.01-0.5 ppm. • Mobile units, which are simple to use, are readily available. • Well demonstrated. • Costs are comparable to other technologies.	• Heavy metal sludge requires further treatment/ disposal. • Relatively long detention times required. • Requires a strictly controlled environment.	Retained	Capable of treating metals in surface water.
Adsorptive Filtration	• Able to reduce metal concentrations as a polishing step after a conventional treatment process.	• Requires backwashing regeneration. • Relatively new technology. • Cannot be used alone because of the high concentrations in the surface water.	Eliminated	Not demonstrated at full-scale.
Microfiltration	• Effective as polishing step	• Expended filters require disposal	Retained	Effective as polishing step.
Groundwater Reinjection	• Can be done nearby the source of contaminated surface water.	• May introduce unacceptable levels of contaminants to groundwater.	Eliminated	Not applicable for discharge of treated surface water.
Discharge to Surface Water	• Is done on site. • Low cost as compared with off-site disposal.	• Permit is required for discharge. • More stringent cleanup levels would apply.	Retained	More stringent cleanup levels.

continued

TABLE 5-19
REMEDIAL TECHNOLOGY SCREENING
SURFACE WATER
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Return to Pond	• Minimal transport of treated surface water.	• Very large temporary storage tank required.	Eliminated	Temporary storage of treated surface water does not add any additional protection to humans or the environment.

Table 5-20
Remedial Technologies Retained for Remedial Alternatives Development
Surface Water
Nitroglycerine Pond and Rocket Paste Area

Feasibility Study
Badger Army Ammunition Plant

General Response Action	Surface Water Technology
Minimal Action	• Institutional Controls/Education Programs/Site Fencing
Treatment	• Ion Exchange • Precipitation • Microfiltration
Discharge	• Discharge to surface water

TABLE 5-21
IDENTIFICATION OF REMEDIAL ALTERNATIVES
SURFACE SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

	MINIMAL ACTION	SOIL COVER	ON-SITE DISPOSAL	OFF-SITE LANDFILL	STABILIZATION/ SOLIDIFICATION	IN SITU STABILIZATION/ SOLIDIFICATION
NG/RPA-SS1	X					
NG/RPA-SS2		X				
NG/RPA-SS3		X	X		X	
NG/RPA-SS4				X		
NG/RPA-SS5		X				X

TABLE 5-22
DEVELOPMENT OF REMEDIAL ALTERNATIVES
SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Remedial Action Objective:

(1) Prevent migration of contaminated surface soil and sediment, and prevent contaminants in sediment from contaminating surface water in ponds.
(2) Prevent human exposure to surface soil and sediment having PB, CR, HG, 24DNT, 26DNT, and CPAH levels that exceed background.
(3) Prevent exposure to terrestrial, aquatic, and semiaquatic receptors to surface soil and sediment having levels of CR, HG, PB, NG, and NNDPA that pose unacceptable risk.
(4) Prevent contamination of groundwater from CR and PB in the surface soil and/or sediment as required by proposed Chapter NR 720.

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
NG/RPA-SS1: Minimal Action	• Surround areas with fencing and post warning signs. • Institutional controls. Implement zoning and deed restrictions. • Education programs. • Annual site inspection, groundwater monitoring, and five-year site reviews.
NG/RPA-SS2: Soil Cover	• Soil cover placed over Rocket Paste Area ditches and pond sediment (2-feet fill, 3 inches topsoil). • Erosion control fabric placed in Main Ditch. All ditches hydroseeded. • Drainage culvert installed in Rocket Paste Pond to maintain drainage integrity. • Post-closure maintenance, groundwater monitoring, and five-year site reviews.

continued

TABLE 5-22
DEVELOPMENT OF REMEDIAL ALTERNATIVES
SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE		DESCRIPTION OF KEY COMPONENTS
NG/RPA-SS3:	Excavation/Solidification/On-Site Disposal	• Treatability testing. • Surface soil/sediment excavation (2-foot depth) in ditches and ponds. • Dewater sediment. • On-site stabilization/solidification at staging area. • On-site disposal of treated surface soil/sediment, at the stabilized soil pile located at the PBG race track area. • Additional cover required at PBG. • Backfill excavations with fill and topsoil.
NG/RPA-SS4:	Excavation/Off-Site Disposal	• Surface soil/sediment excavation (2-foot depth) in ditches and ponds. • Sediment dewatering. • Off-site disposal of excavated surface soil/sediment. • Backfill excavations with fill and topsoil.
NG/RPA-SS5:	In Situ Stabilization/Solidification	• Treatability testing. • Stabilize/solidify contaminated surface soil and sediment in situ. • Soil cover over treated soil/sediment. • Post-closure maintenance, groundwater monitoring, and five-year site reviews.

TABLE 5-23
IDENTIFICATION OF REMEDIAL ALTERNATIVES
SURFACE WATER
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

	Minimal Action	Ion Exchange	Precipitation	Microfiltration	Discharge to Surface Water
NG/RPA-SW1	X				
NG/RPA-SW2			X	X	X
NG/RPA-SW3		X			X

TABLE 5-24
DEVELOPMENT OF REMEDIAL ALTERNATIVES
SURFACE WATER
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Remedial Action Objective:

(1) Reduce the concentrations of AL, FE, HG, MN, and PB in surface water at the Nitroglycerine Pond to levels that result in acceptable risk for aquatic and semi-aquatic receptors.

(2) Reduce the concentrations of AL, CR, CU, FE, MN, PB, and ZN in surface water at the Rocket Paste Pond to levels that result in acceptable risk for aquatic and semi-aquatic receptors.

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
NG/RPA-SW1: Minimal Action	• Surround areas with fencing and post warning signs. • Institutional controls. Implement zoning and deed restrictions. • Education programs. • Annual site inspection, surface water monitoring, and five-year site reviews.
NG/RPA-SW2: Precipitation/Microfiltration	• Treatability testing. • Treat water using a mobile precipitation system in series with a microfiltration polishing system. • Discharge treated water to surface water.
NG/RPA-SW3: Ion Exchange	• Treatability testing. • Treat water using mobile ion exchange system. • Discharge treated water to surface water.

Note:

Full compounds names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

TABLE 5-25
SCREENING OF REMEDIAL ALTERNATIVES
SURFACE SOIL AND SEDIMENT
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative NG/RPA-SS1: Minimal Action: This alternative consists of institutional controls, educational programs, groundwater monitoring, and five-year site reviews. Fencing and warning signs would enclose those areas identified as posing a risk to public health.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Public access to affected areas would be restricted. • Low potential for exposure to contaminants during implementation. • Institutional controls would reduce the potential for future land development. • Educational programs would increase public awareness about contamination.	Advantages • Would be easy to implement because no soil remediation is required. • Services and material for fencing are readily available.	Advantages • Short-term cost for administration of institutional controls, educational programs, and groundwater monitoring and maintenance is relatively low.
Disadvantages • Would not reduce mobility, toxicity, or volume of contaminants. • Does not achieve remedial action objectives.	Disadvantages • Long-term monitoring and maintenance would be required.	Disadvantages • Future remedial actions may be more costly. • Long-term liability associated with waste.

CONCLUSION: The minimal action alternative is **retained** so as to be used as a baseline for comparison with the remaining remedial alternatives for surface soil and sediment at the Nitroglycerine Pond and Rocket Paste Area.

continued

TABLE 5-25
SCREENING OF REMEDIAL ALTERNATIVES
SURFACE SOIL AND SEDIMENT
ROCKET PASTE AREA/NITROGLYCERINE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative NG/RPA-SS2: Soil Cover: This alternative consists of placing a soil cover over the ditches and dewatered ponds to prevent direct contact and incidental ingestion of contaminated surface soil and sediment by ecological and/or public receptors. This alternative also includes five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Soil cover would isolate contaminated soil from potential human and ecological receptors.	Advantages • Would be easy to implement. • Soil cover would require minimal maintenance for the long-term. • Equipment and material readily available.	Advantages • Inexpensive alternative for achieving human health and ecological remedial action objectives.
Disadvantages • Would not reduce the toxicity or volume of contaminants. • Does not achieve groundwater remedial action objective.	Disadvantages • Would require long-term monitoring and maintenance provisions.	Disadvantages • Long-term liability associated with waste.

CONCLUSION: Because this alternative achieves human health and ecological remedial action objectives and would be easily implemented, it is **retained** for detailed analysis.

continued

TABLE 5-25
SCREENING OF REMEDIAL ALTERNATIVES
SURFACE SOIL AND SEDIMENT
ROCKET PASTE AREA/NITROGLYCERINE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative NG/RPA-SS3: Excavation/Solidification/On-Site Disposal: This alternative consists of excavating contaminated surface soil and sediments, treating using stabilization/solidification and transporting the contaminated soil for on-site disposal at the Propellant Burning Ground.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives. • No significant long-term threat to human health and the environment. • Reduces mobility of the contaminants.	Advantages • Surface soils/sediment are easily removed with conventional excavation equipment. • Excavation, treatment, and transportation services are readily available. • Stabilization/solidification is a proven, reliable technology for treating metals in soil and sediment.	Advantages • Less expensive than off-site disposal.
Disadvantages • Would not reduce the toxicity of contaminants. • Volume of contaminated soil/ sediment will increase by 20-30% during treatment. • Potential for direct human contact with contaminated soil/sediment during treatment.	Disadvantages • Approximately 100,000 yd^3 would be transported for disposal. • Treatability study required to determine the optimal mixture of reagents.	Disadvantages • Long-term maintenance costs associated with stored wastes.

CONCLUSION: This alternative is **retained** for detailed analysis.

continued

TABLE 5-25
SCREENING OF REMEDIAL ALTERNATIVES
SURFACE SOIL AND SEDIMENT
ROCKET PASTE AREA/NITROGLYCERINE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative NG/RPA-SS4: Excavation/Off-Site Disposal: This alternative consists of excavating contaminated surface soil and sediment and transporting for disposal at a RCRA permitted facility.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives. • No significant long-term threat to human health and the environment. • Would reduce mobility by placing in a secure landfill.	Advantages • Surface soils and sediment are easily removed using conventional excavation equipment. • Transportation services readily available.	Advantages • None.
Disadvantages • Would not reduce toxicity or volume of contaminants. • Potential for direct human contact with contaminated soil/sediment during excavation.	Disadvantages • Approximately 73,000 yd^3 would be transported for off-site disposal. • May exceed landfill capacity.	Disadvantages • Most expensive alternative.

CONCLUSION: This alternative is **retained** for detailed analysis.

continued

TABLE 5-25
SCREENING OF REMEDIAL ALTERNATIVES
SURFACE SOIL AND SEDIMENT
ROCKET PASTE AREA/NITROGLYCERINE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative NG/RPA-SS5: In Situ Stabilization/Solidification: This alternative consists of treating contaminated soil in situ by stabilization/solidification. This alternative also includes groundwater monitoring and five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Effectively achieves remedial action objectives because contaminants in the treatment residuals are unavailable to receptors. • In situ Stabilization/Solidification reduces the mobility of contaminants. • No significant long-term threat to human health and the environment.	Advantages • Not subject to RCRA Land Disposal Restrictions. • Surface soils/sediments are well within depth capability of in situ stabilization/solidification.	Advantages • Least costly of the three alternatives which meet remedial action objectives.
Disadvantages • Would not reduce toxicity of contaminants. • Volume of contaminated soil increased by 20-30%. • Potential for direct human contact with contaminated soil/sediment during treatment.	Disadvantages • Would require long-term monitoring and maintenance provisions. • Treatability study required to determine the optimal mixture of reagents. • Reagent/waste ratios can be difficult to control and monitor during the in situ process.	Disadvantages • Long-term costs associated with operation and maintenance of site after treatment.

CONCLUSION: This alternative is **retained for** detailed analysis.

Notes:

BAAP = Badger Army Ammunition Plant
PB = Lead
RCRA = Resource Conservation and Recovery Act
TCLP = Toxicity Characteristic Leaching Procedure

Table 5-26
Summary of Remedial Alternatives Screening
Surface Soil and Sediment
Nitroglycerine Pond and Rocket Paste Area

Feasibility Study
Badger Army Ammunition Plant

Alternative	Status
Alternative NG/RPA-SS1: Minimal Action	Retained for detailed analysis.
Alternative NG/RPA-SS2: Soil Cover	Retained for detailed analysis.
Alternative NG/RPA-SS3: Excavation/Solidification/On-Site Disposal	Retained for detailed analysis.
Alternative NG/RPA-SS4: Excavation/Off-Site Disposal	Retained for detailed analysis.
Alternative NG/RPA-SS5: In Situ Stabilization/ Solidification	Retained for detailed analysis.

TABLE 5-27
SCREENING OF REMEDIAL ALTERNATIVES
SURFACE WATER
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative NG/RPA-SW1: Minimal Action: This alternative consists of institutional controls, educational programs, groundwater monitoring, and five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Institutional controls would reduce the potential for future surface water use. • Educational program would increase public awareness about contaminated surface water.	Advantages • Would be easy to implement because no remedial actions are required. • Services and material readily available.	Advantages • Minimal cost for administration of institutional controls, and educational programs.
Disadvantages • Does not achieve remedial objectives. • Would not reduce mobility, toxicity, or volume of chemicals in the surface water. • Would not reduce the potential for surface water migration.	Disadvantages • Long-term monitoring and maintenance provisions would be required. • May require future surface water remediation.	Disadvantages • Future remedial actions may be more costly due to continuing chemical migration. • Long-term costs associated with operation and maintenance of monitoring systems.

CONCLUSION: The minimal action alternative is **retained** as a baseline for comparison with the remaining alternatives for surface water at the Nitroglycerine Pond and Rocket Paste Area.

Note:

SARA = Superfund Amendments and Reauthorization Act

continued

TABLE 5-27
SCREENING OF REMEDIAL ALTERNATIVES
SURFACE WATER
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative NG/RPA-SW2: Precipitation/Microfiltration: This alternative consists of surface water treatment using precipitation in conjunction with microfiltration followed by discharging treated water back to surface water.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Generally, precipitation can remove heavy metals to levels in the range of 0.1 to 0.5 ppm. Microfiltration would then be used as a polishing step to attain RGs. • Reduces waste volume from a large quantity of contaminated water to a smaller volume of concentrated sludge. • Effective for a wide variety of concentrations.	Advantages • Mobile treatment facilities available. • Well demonstrated technologies, commonly used for removal of heavy metals in industrial and municipal wastestreams, as well as wastestreams from hazardous waste sites. • Several experienced vendors are available.	Advantages • Operating and maintenance costs potentially low.
Disadvantages • Does not reduce toxicity of heavy metals. • Potential worker safety hazards associated with operating the treatment system.	Disadvantages • Some organic compounds, as well as cyanide and other ions, can complex with metals and inhibit the precipitation process. • Resulting sludge/filters must be dewatered and treated and/or disposed. • May require treatability investigations.	Disadvantages • High capital costs.

CONCLUSION: This alternative achieves the remedial action alternatives, and is therefore **retained** for detailed analysis.

TABLE 5-27
SCREENING OF REMEDIAL ALTERNATIVES
SURFACE WATER
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative NG/RPA-SW3: Ion Exchange: This alternative consists of surface water treatment using ion exchange technology followed by discharging treated water back to surface water.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages	Advantages	Advantages
• Ion exchange effective in reducing metals contamination in water	• Mobile treatment facilities available.	• Operating and monitoring costs potentially low.
• Resulting treated water typically is of good quality.	• Well demonstrated technology.	
	• Several vendors available.	
Disadvantages	Disadvantages	Disadvantages
• Does not reduce toxicity of heavy metals.	• Resulting non-regenerative sludge requires disposal.	• High capital costs.
• Resin requires disposal or regeneration.	• May require treatability investigation.	
• Potential worker safety hazards working with the untreated water.		
• May not be able to achieve levels prescribed by remediation goals.		

CONCLUSION: This alternative achieves remedial action alternatives and is therefore **retained** for detailed analysis.

TABLE 5-28
SUMMARY OF REMEDIAL ALTERNATIVES SCREENING
SURFACE WATER
NITROGLYCERINE POND AND ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	STATUS
NG/RPA-SW1: Minimal Action	Retained for Detailed Analysis
NG/RPA-SW2: Precipitation/Microfiltration	Retained for Detailed Analysis
NG/RPA-SW3: Ion Exchange	Retained for Detailed Analysis

TABLE 5-29
SUMMARY OF CONTAMINATION ASSESSMENT THROUGH REMEDIAL ALTERNATIVES SCREENING
NITROGLYCERINE POND/ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

	CONTAMINATED MEDIA AT NITROGLYCERINE POND/ROCKET PASTE AREA		
RI/FS COMPONENT	SURFACE SOIL	SEDIMENT	SURFACE WATER
Identification of Contaminants of Concern	• SVOCs • Inorganics	• SVOCs • Inorganics	• Inorganics
Risk Assessment Results	• PB, 24DNT, 26DNT, CPAH, and NNDPA are a threat to humans. • PB, NG, HG, CR, NNDPA, 26DNT, and 24DNT all exceed acceptable ecological risk levels. • PB, CR, and 24DNT all exceed acceptable groundwater risk levels.	• CR, HG, PB all exceed acceptable ecological risk levels. • PB also a threat to humans. • CR and PB exceed acceptable groundwater risk levels. • Levels of SVOCs do not pose an unacceptable health risk.	• AL, HG, CR, CU, FE, MN, PB, and ZN all exceed acceptable ecological risk standards.
Remedial Action Objectives	• Prevent migration of contaminated soil by erosion. • Reduce exposure to PB, 24DNT, 26DNT, CPAH, and NNDPA concentration to acceptable risk levels for humans. • Reduce exposure to concentrations of PB, CR, HG, NG, 24DNT, 26DNT and NNDPA to acceptable risk levels for terrestrial organisms.	• Prevent migration of contaminated sediment into drainageways downgradient of ponds. • Prevent contaminants in sediment from contaminating surface water in ponds. • Reduce exposure of concentrations of CR, HG, and PB in sediments at the Nitroglycerine Pond to levels resulting in acceptable risk for aquatic and semiaquatic receptors.	• Reduce AL, HG, MN, PB, CR, CU, FE, and ZN concentrations to levels resulting in acceptable risk for aquatic and semiaquatic receptors.

continued

TABLE 5-29
SUMMARY OF CONTAMINATION ASSESSMENT THROUGH REMEDIAL ALTERNATIVES SCREENING NITROGLYCERINE POND/ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

RI/FS COMPONENT	CONTAMINATED MEDIA AT NITROGLYCERINE POND/ROCKET PASTE AREA		
	SURFACE SOIL	SEDIMENT	SURFACE WATER
Remedial Action Objectives	• Reduce exposure to PB, CR, and 24DNT to acceptable levels for groundwater.	• Reduce exposure to PB concentration in Rocket Paste Pond to acceptable risk level for humans. • Reduce exposure to CR and PB to acceptable levels for groundwater.	
Remedial Technologies Retained After Screening	• Soil Cover • Off-Site Landfill • On-Site Disposal • Solidification/ Stabilization • In-Situ Solidification/ Stabilization	• Soil Cover • On-Site Disposal • Off-Site Landfill • Solidification/ Stabilization • In-Situ Solidification/ Stabilization	• Precipitation • Ion Exchange • Microfiltration • Return water to surface water
Remedial Alternatives Developed	• Minimal Action • Soil Cover • Excavation/Solidification/On-Site Disposal • Excavation/Off-site Disposal • In-situ Solidification/ Stabilization	• Minimal Action • Soil Cover • Excavation/Solidification/On-Site Disposal • Excavation/Off-site Disposal • In-Situ Solidification/ Stabilization	• Minimal Action • Precipitation/ Microfiltration • Ion Exchange

continued

TABLE 5-29
SUMMARY OF CONTAMINATION ASSESSMENT THROUGH REMEDIAL ALTERNATIVES SCREENING NITROGLYCERINE POND/ROCKET PASTE AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

RI/FS COMPONENT	CONTAMINATED MEDIA AT NITROGLYCERINE POND/ROCKET PASTE AREA		
	SURFACE SOIL	SEDIMENT	SURFACE WATER
Remedial Alternatives Retained After Screening	• Minimal Action • Soil Cover • Excavation/ Solidification/On-Site Disposal • Excavation/Off-site Disposal • In-situ solidification/ stabilization	• Minimal Action • Soil Cover • Excavation/Solidificati on/ On-Site Disposal • Excavation/Off-site Disposal • In-situ solidification/ stabilization	• Minimal Action • Precipitation/ Microfiltration • Ion Exchange

Note:

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

MAP CODE	SAMPLE NUMBER	MAP CODE	SAMPLE NUMBER	MAP CODE	SAMPLE NUMBER	MAP CODE	SAMPLE NUMBER	MAP CODE	SAMPLE NUMBER
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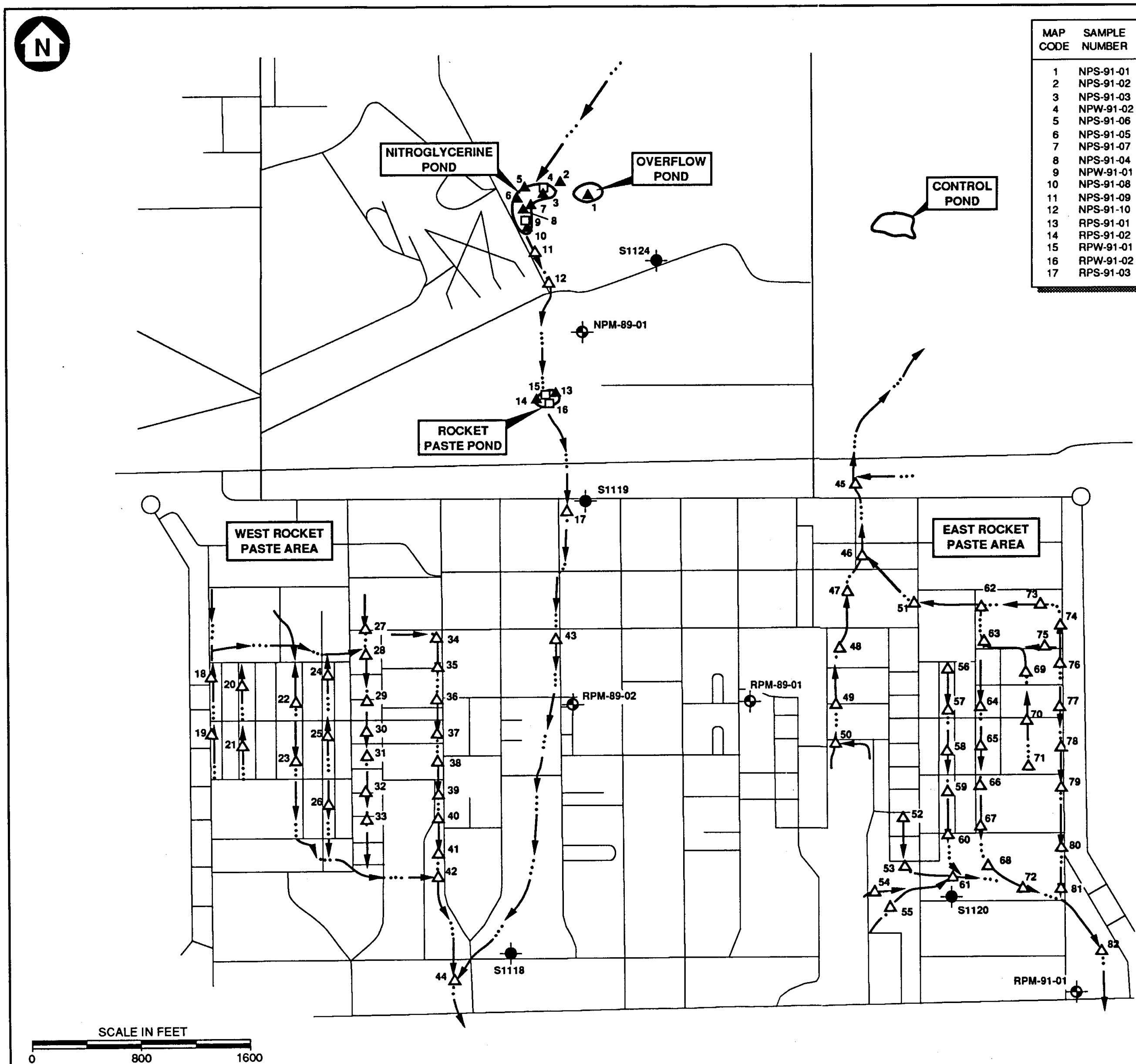
2	NPS-91-02	19	RPS-91-35	36	RPS-91-18	53	RPS-91-61	70	RPS-91-45
3	NPS-91-03	20	RPS-91-32	37	RPS-91-19	54	RPS-91-62	71	RPS-91-46
4	NPW-91-02	21	RPS-91-33	38	RPS-91-06	55	RPS-91-63	72	RPS-91-47
5	NPS-91-06	22	RPS-91-30	39	RPS-91-20	56	RPS-91-55	73	RPS-91-36
6	NPS-91-05	23	RPS-91-31	40	RPS-91-21	57	RPS-91-56	74	RPS-91-37
7	NPS-91-07	24	RPS-91-28	41	RPS-91-22	58	RPS-91-57	75	RPS-91-44
8	NPS-91-04	25	RPS-91-10	42	RPS-91-07	59	RPS-91-14	76	RPS-91-38
9	NPW-91-01	26	RPS-91-29	43	RPS-91-04	60	RPS-91-58	77	RPS-91-39
10	NPS-91-08	27	RPS-91-08	44	RPS-91-16	61	RPS-91-59	78	RPS-91-40
11	NPS-91-09	28	RPS-91-23	45	RPS-91-11	62	RPS-91-48	79	RPS-91-41
12	NPS-91-10	29	RPS-91-24	46	RPS-91-64	63	RPS-91-49	80	RPS-91-42
13	RPS-91-01	30	RPS-91-25	47	RPS-91-65	64	RPS-91-50	81	RPS-91-43
14	RPS-91-02	31	RPS-91-09	48	RPS-91-66	65	RPS-91-13	82	RPS-91-15
15	RPW-91-01	32	RPS-91-26	49	RPS-91-67	66	RPS-91-51		
16	RPW-91-02	33	RPS-91-27	50	RPS-91-68	67	RPS-91-52		
17	RPS-91-03	34	RPS-91-05	51	RPS-91-54	68	RPS-91-53		



LEGEND

PAVED ROAD OR TRAMWAY

DRAINAGE DITCH

S1119 EXISTING MONITORING WELLS

RPM-89-02 NEW MONITORING WELLS

SEDIMENT SAMPLE

SURFACE SOIL SAMPLE

SURFACE WATER SAMPLE

NOTES:
1. BASE MAP FROM 300-SCALE SITE TOPOGRAPHIC PLAN PROVIDED BY OLIN CORPORATION.
2. S1100 SERIES AND 81 SERIES WELL LOCATIONS BASED ON MEP (TSAI, 1988)
3. 1989 AND 91 SERIES WELL LOCATIONS BASED ON VIERBICHER SURVEY DATA (APPENDIX F, RI REPORT [ABB-ES, 1993a]).
4. SURFACE SOIL AND SURFACE WATER SAMPLE LOCATIONS BASED ON FIELD SURVEY CONDUCTED BY ABB-ES.

FIGURE 5-1
SITE LOCATION PLAN AND SAMPLE LOCATIONS NITROGLYCERINE POND AND ROCKET PASTE AREA FEASIBILITY STUDY BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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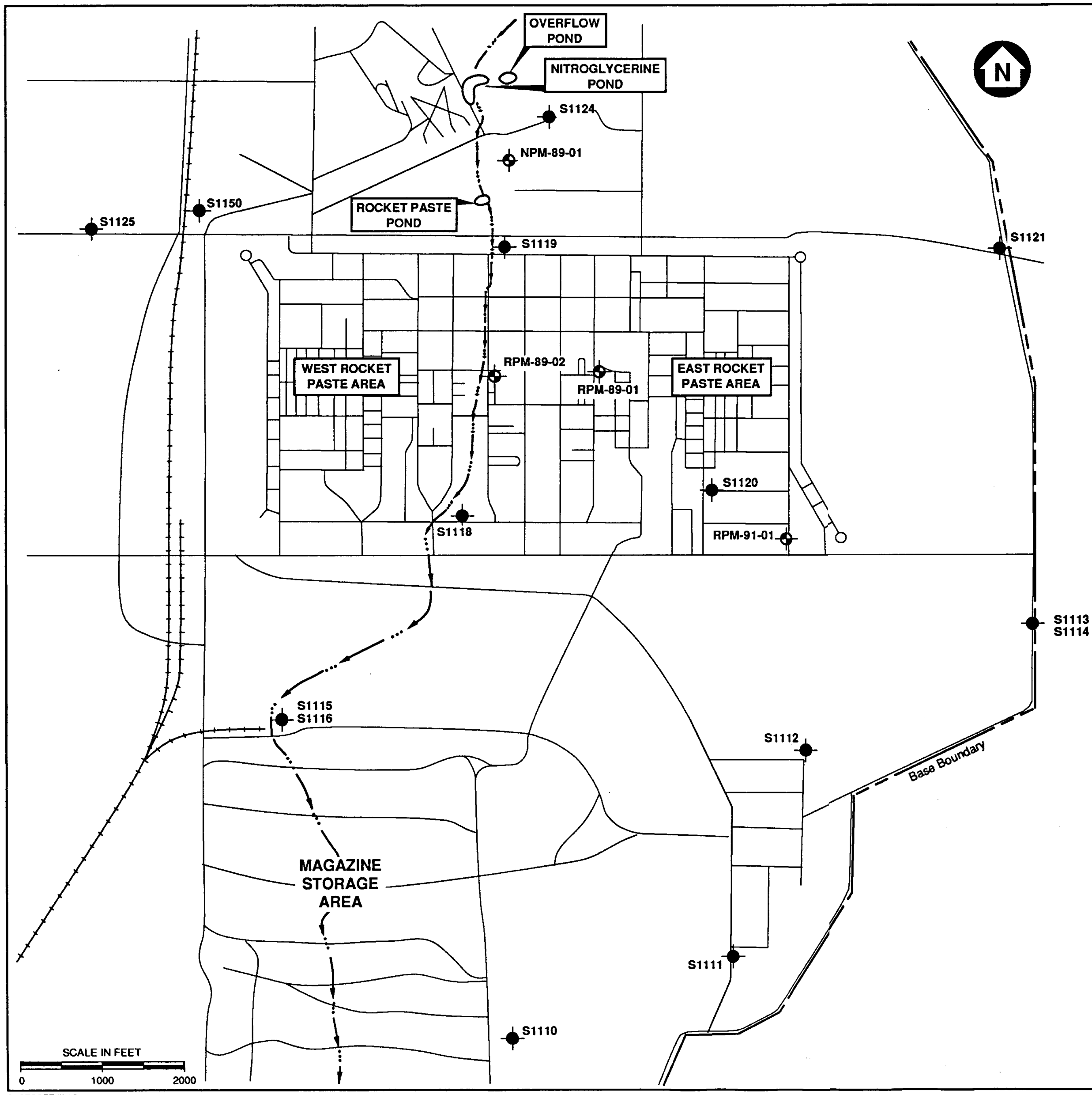

LEGEND

- PAVED ROAD OR TRAMWAY
- DRAINAGE DITCH
- S1119 — EXISTING MONITORING WELL LOCATION AND DESIGNATION
- RPM-89-02 — NEW MONITORING WELL LOCATION AND DESIGNATION

NOTES:

1. BASE MAP FROM 300-SCALE SITE TOPOGRAPHIC PLAN PROVIDED BY OLIN CORPORATION.
2. S1100 SERIES AND 81 SERIES WELL LOCATIONS BASED ON MEP (TSAI, 1988).
3. 1989 AND 91 SERIES WELL LOCATIONS BASED ON VIERBICHER SURVEY DATA (APPENDIX F, RI REPORT [ABB-ES, 1993a]).
4. NEW MONITORING WELLS INSTALLED UNDER THE DIRECTION OF ABB-ES.
5. EXISTING MONITORING WELLS INSTALLED UNDER THE DIRECTION OF OLIN CORPORATION.
6. FUDS PIEZOMETERS INSTALLED UNDER THE DIRECTION OF COE - ST. PAUL DISTRICT.

FIGURE 5-2
MONITORING WELL LOCATIONS
NITROGLYCERINE POND AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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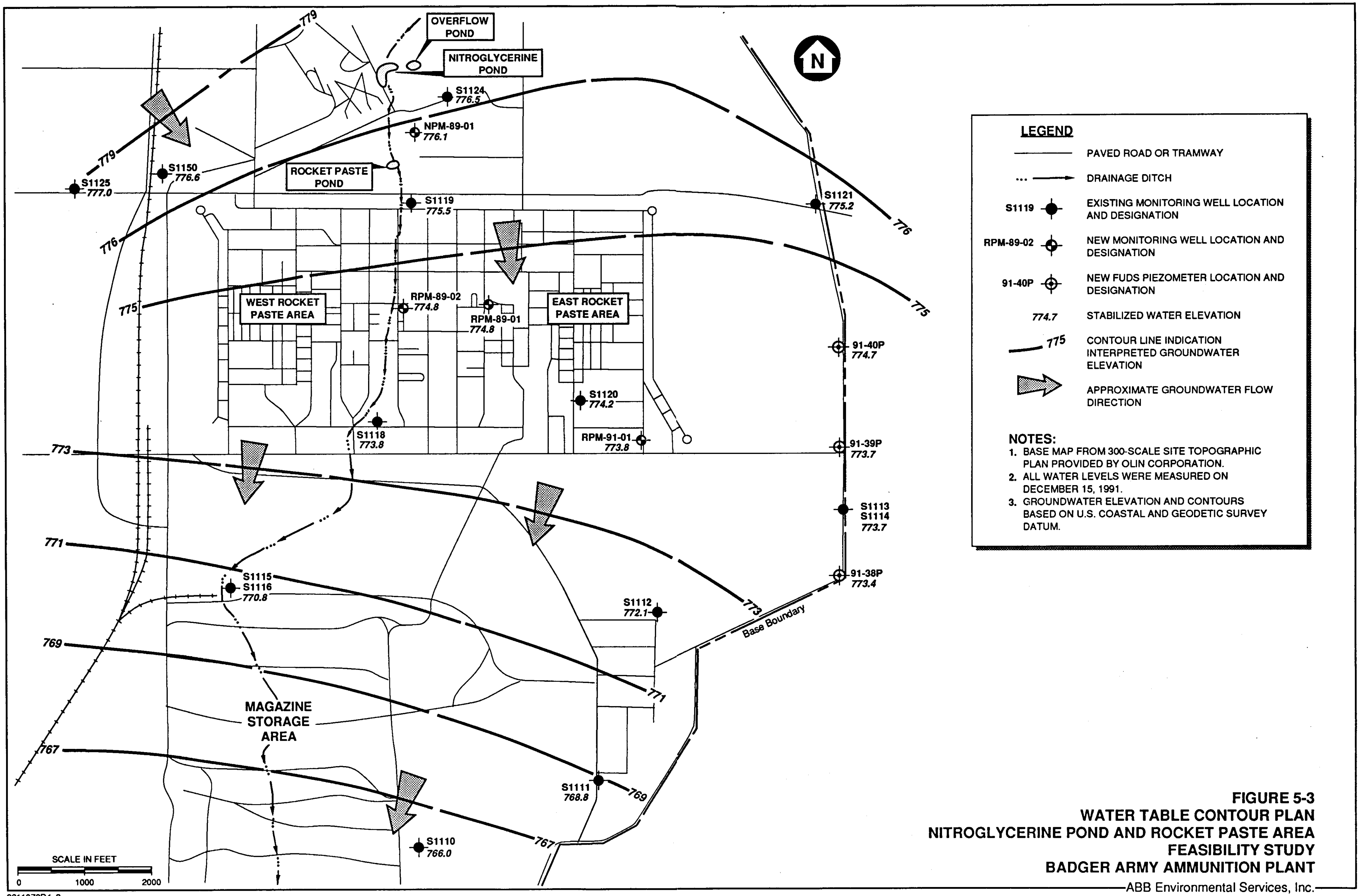

FIGURE 5-3
WATER TABLE CONTOUR PLAN
NITROGLYCERINE POND AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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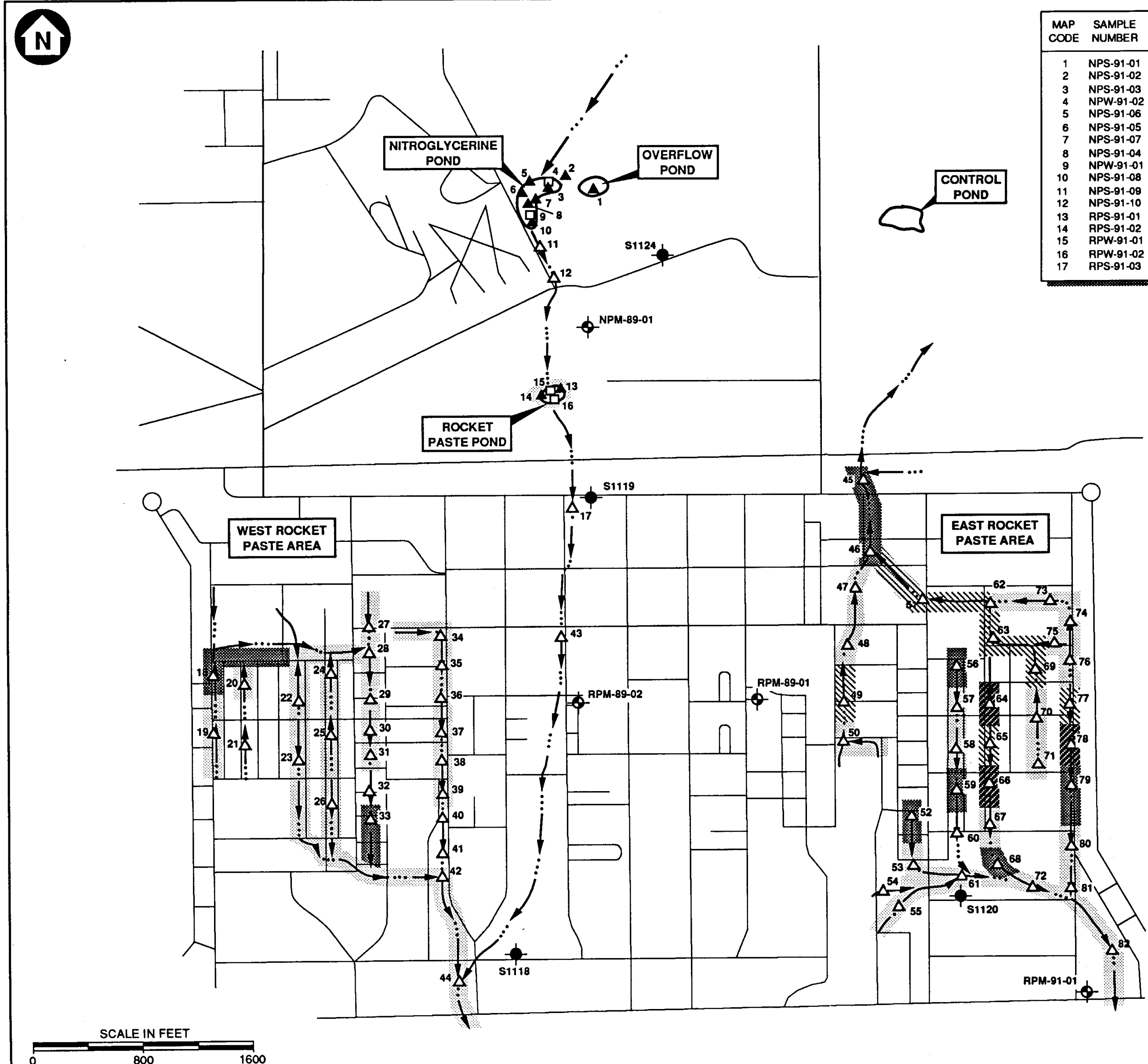

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3	NPS-91-03	20	RPS-91-32	37	RPS-91-19	54	RPS-91-62	71	RPS-91-46
4	NPW-91-02	21	RPS-91-33	38	RPS-91-06	55	RPS-91-63	72	RPS-91-47
5	NPS-91-06	22	RPS-91-30	39	RPS-91-20	56	RPS-91-55	73	RPS-91-36
6	NPS-91-05	23	RPS-91-31	40	RPS-91-21	57	RPS-91-56	74	RPS-91-37
7	NPS-91-07	24	RPS-91-28	41	RPS-91-22	58	RPS-91-57	75	RPS-91-44
8	NPS-91-04	25	RPS-91-10	42	RPS-91-07	59	RPS-91-14	76	RPS-91-38
9	NPW-91-01	26	RPS-91-29	43	RPS-91-04	60	RPS-91-58	77	RPS-91-39
10	NPS-91-08	27	RPS-91-08	44	RPS-91-16	61	RPS-91-59	78	RPS-91-40
11	NPS-91-09	28	RPS-91-23	45	RPS-91-11	62	RPS-91-48	79	RPS-91-41
12	NPS-91-10	29	RPS-91-24	46	RPS-91-64	63	RPS-91-49	80	RPS-91-42
13	RPS-91-01	30	RPS-91-25	47	RPS-91-65	64	RPS-91-50	81	RPS-91-43
14	RPS-91-02	31	RPS-91-09	48	RPS-91-66	65	RPS-91-13	82	RPS-91-15
15	RPW-91-01	32	RPS-91-26	49	RPS-91-67	66	RPS-91-51		
16	RPW-91-02	33	RPS-91-27	50	RPS-91-68	67	RPS-91-52		
17	RPS-91-03	34	RPS-91-05	51	RPS-91-54	68	RPS-91-53		

LEGEND

- PAVED ROAD OR TRAMWAY
- DRAINAGE DITCH
- S1119 EXISTING MONITORING WELLS
- RPM-89-02 NEW MONITORING WELLS
- SEDIMENT SAMPLE
- SURFACE SOIL SAMPLE
- SURFACE WATER SAMPLE

NNDPA CONCENTRATIONS

- >1000 µg/g
- 100 to 999 µg/g
- 10 to 99 µg/g
- >CRL to 9.9 µg/g

NOTE:
1. SEE RI REPORT FOR CHEMICAL DATA SUMMARY (ABB-ES, 1993a).

FIGURE 5-4
NNDPA CONCENTRATIONS IN SURFACE SOIL NITROGLYCERINE POND AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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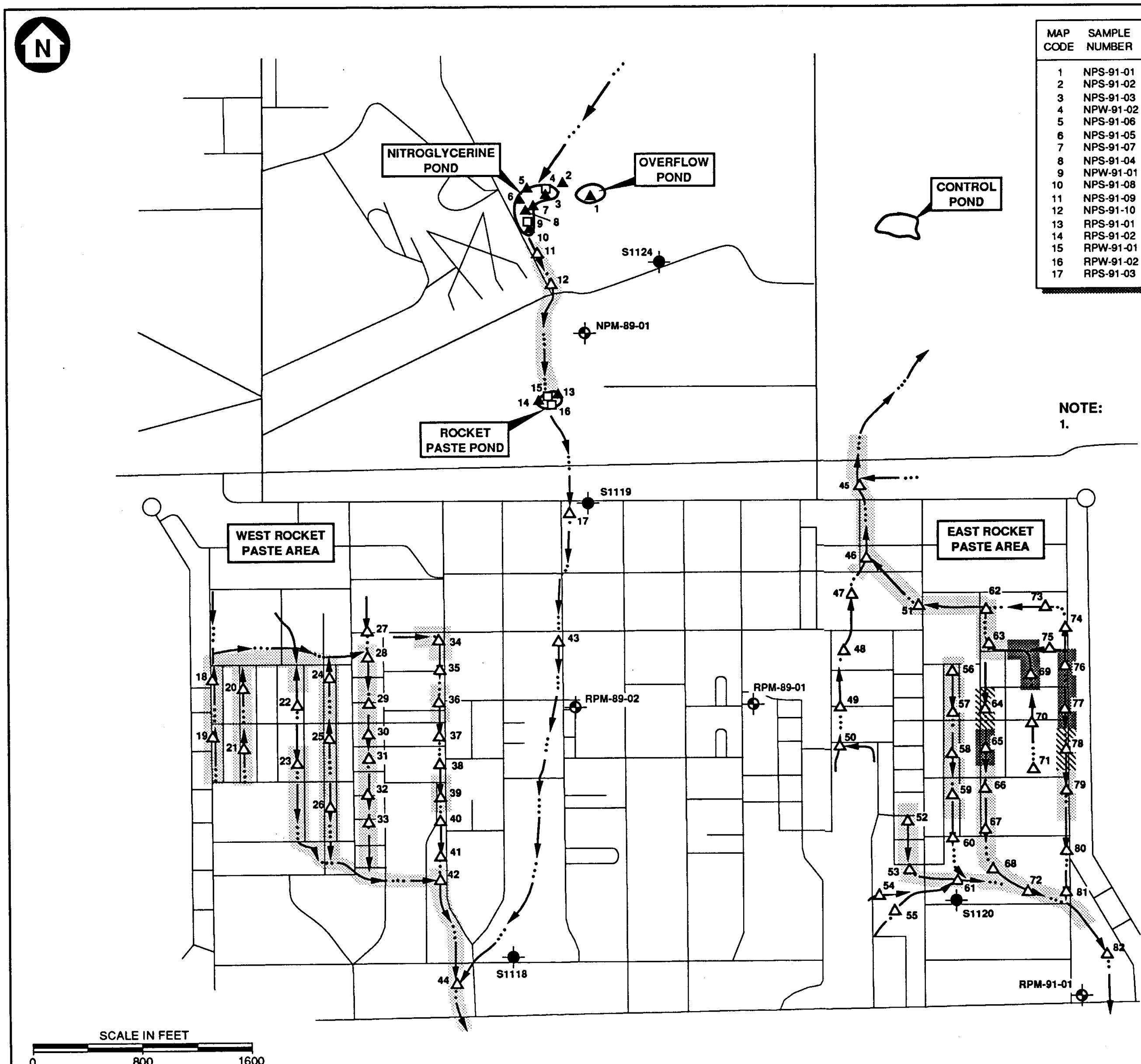

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6	NPS-91-05	23	RPS-91-31	40	RPS-91-21	57	RPS-91-56	74	RPS-91-37
7	NPS-91-07	24	RPS-91-28	41	RPS-91-22	58	RPS-91-57	75	RPS-91-44
8	NPS-91-04	25	RPS-91-10	42	RPS-91-07	59	RPS-91-14	76	RPS-91-38
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11	NPS-91-09	28	RPS-91-23	45	RPS-91-11	62	RPS-91-48	79	RPS-91-41
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13	RPS-91-01	30	RPS-91-25	47	RPS-91-65	64	RPS-91-50	81	RPS-91-43
14	RPS-91-02	31	RPS-91-09	48	RPS-91-66	65	RPS-91-13	82	RPS-91-15
15	RPW-91-01	32	RPS-91-26	49	RPS-91-67	66	RPS-91-51		
16	RPW-91-02	33	RPS-91-27	50	RPS-91-68	67	RPS-91-52		
17	RPS-91-03	34	RPS-91-05	51	RPS-91-54	68	RPS-91-53		

NOTE:
1. SEE RI REPORT FOR CHEMICAL DATA SUMMARY (ABB-ES, 1993a).

FIGURE 5-5
NG CONCENTRATIONS IN SURFACE SOIL NITROGLYCERINE POND AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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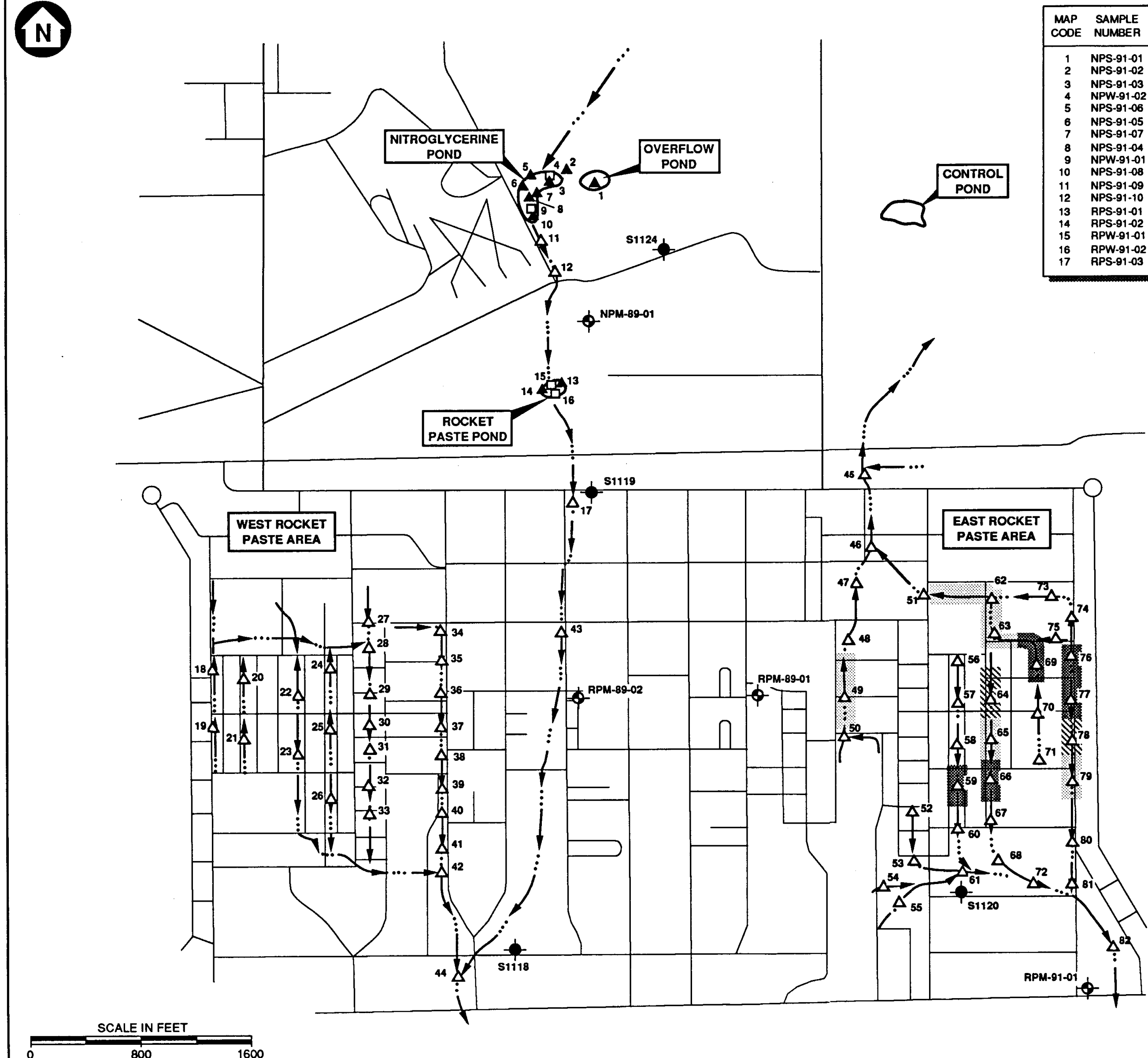

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4	NPW-91-02	21	RPS-91-33	38	RPS-91-06	55	RPS-91-63	72	RPS-91-47
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6	NPS-91-05	23	RPS-91-31	40	RPS-91-21	57	RPS-91-56	74	RPS-91-37
7	NPS-91-07	24	RPS-91-28	41	RPS-91-22	58	RPS-91-57	75	RPS-91-44
8	NPS-91-04	25	RPS-91-10	42	RPS-91-07	59	RPS-91-14	76	RPS-91-38
9	NPW-91-01	26	RPS-91-29	43	RPS-91-04	60	RPS-91-58	77	RPS-91-39
10	NPS-91-08	27	RPS-91-08	44	RPS-91-16	61	RPS-91-59	78	RPS-91-40
11	NPS-91-09	28	RPS-91-23	45	RPS-91-11	62	RPS-91-48	79	RPS-91-41
12	NPS-91-10	29	RPS-91-24	46	RPS-91-64	63	RPS-91-49	80	RPS-91-42
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14	RPS-91-02	31	RPS-91-09	48	RPS-91-66	65	RPS-91-13	82	RPS-91-15
15	RPW-91-01	32	RPS-91-26	49	RPS-91-67	66	RPS-91-51		
16	RPW-91-02	33	RPS-91-27	50	RPS-91-68	67	RPS-91-52		
17	RPS-91-03	34	RPS-91-05	51	RPS-91-54	68	RPS-91-53		

LEGEND

- PAVED ROAD OR TRAMWAY
- DRAINAGE DITCH
- S1119 EXISTING MONITORING WELLS
- RPM-89-02 NEW MONITORING WELLS
- SEDIMENT SAMPLE
- SURFACE SOIL SAMPLE
- SURFACE WATER SAMPLE

TOTAL DNT CONCENTRATIONS

- >100 µg/g
- 10 to 99 µg/g
- >CRL TO 9.9 µg/g

NOTE:

1. SEE RI REPORT FOR CHEMICAL DATA SUMMARY (ABB-ES, 1993a).

FIGURE 5-6
TOTAL DNT CONCENTRATIONS IN SURFACE SOIL NITROGLYCERINE POND AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407005D(a) abc g

MAP CODE	SAMPLE NUMBER	MAP CODE	SAMPLE NUMBER	MAP CODE	SAMPLE NUMBER	MAP CODE	SAMPLE NUMBER	MAP CODE	SAMPLE NUMBER
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3	NPS-91-03	20	RPS-91-32	37	RPS-91-19	54	RPS-91-62	71	RPS-91-46
4	NPW-91-02	21	RPS-91-33	38	RPS-91-06	55	RPS-91-63	72	RPS-91-47
5	NPS-91-06	22	RPS-91-30	39	RPS-91-20	56	RPS-91-55	73	RPS-91-36
6	NPS-91-05	23	RPS-91-31	40	RPS-91-21	57	RPS-91-56	74	RPS-91-37
7	NPS-91-07	24	RPS-91-28	41	RPS-91-22	58	RPS-91-57	75	RPS-91-44
8	NPS-91-04	25	RPS-91-10	42	RPS-91-07	59	RPS-91-14	76	RPS-91-38
9	NPW-91-01	26	RPS-91-29	43	RPS-91-04	60	RPS-91-58	77	RPS-91-39
10	NPS-91-08	27	RPS-91-08	44	RPS-91-16	61	RPS-91-59	78	RPS-91-40
11	NPS-91-09	28	RPS-91-23	45	RPS-91-11	62	RPS-91-48	79	RPS-91-41
12	NPS-91-10	29	RPS-91-24	46	RPS-91-64	63	RPS-91-49	80	RPS-91-42
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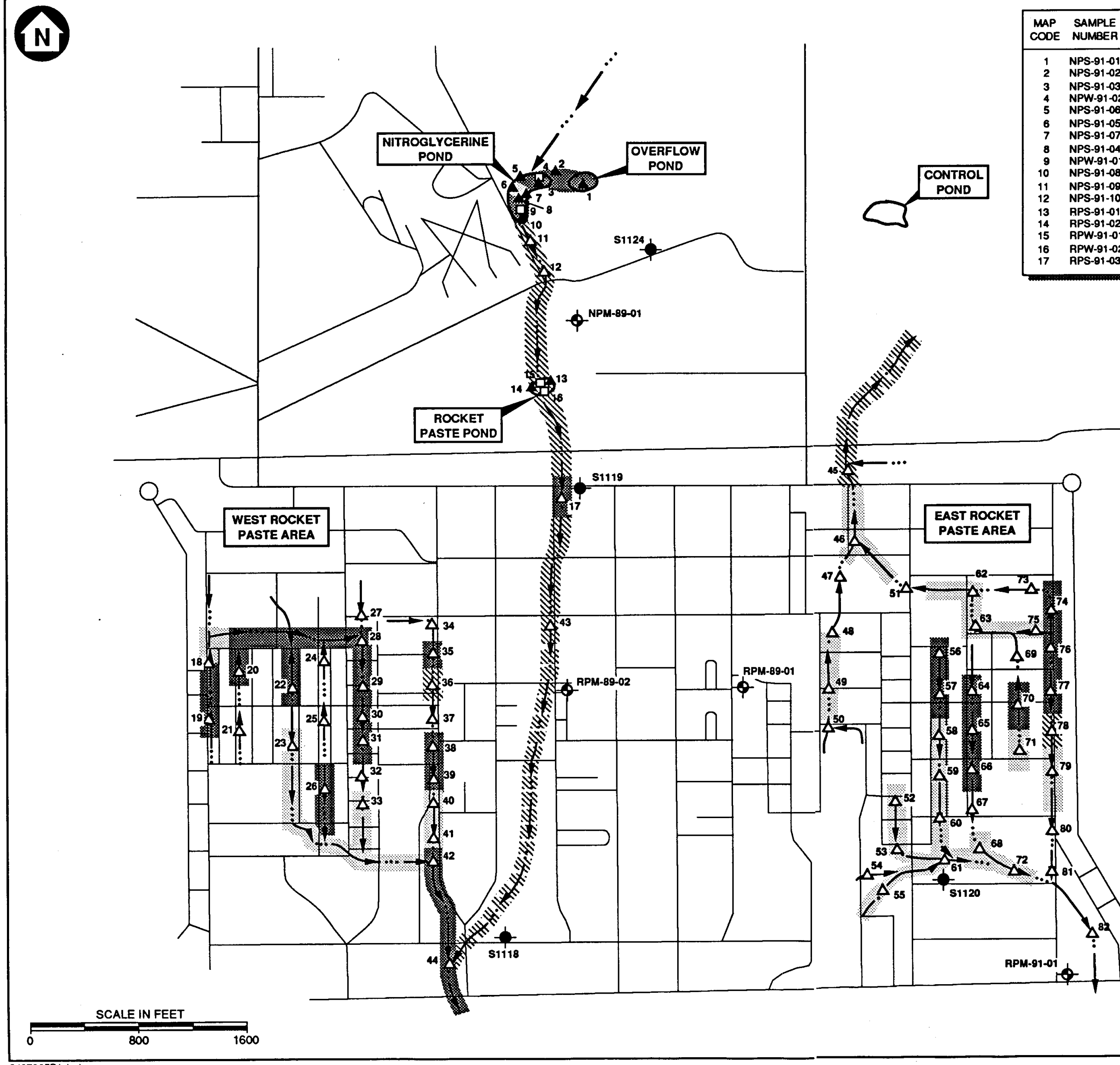
14	RPS-91-02	31	RPS-91-09	48	RPS-91-66	65	RPS-91-13	82	RPS-91-15
15	RPW-91-01	32	RPS-91-26	49	RPS-91-67	66	RPS-91-51		
16	RPW-91-02	33	RPS-91-27	50	RPS-91-68	67	RPS-91-52		
17	RPS-91-03	34	RPS-91-05	51	RPS-91-54	68	RPS-91-53		



LEGEND

PAVED ROAD OR TRAMWAY

DRAINAGE DITCH

S1119 EXISTING MONITORING WELLS

RPM-89-02 NEW MONITORING WELLS

SEDIMENT SAMPLE

SURFACE SOIL SAMPLE

SURFACE WATER SAMPLE

PB CONCENTRATIONS

>1000 µg/g

100 to 999 µg/g

30 to 99.9 µg/g

ESTIMATED CONCENTRATION

NOTE:

1. SEE RI REPORT FOR CHEMICAL DATA SUMMARY (ABB-ES, 1993a).

FIGURE 5-7
TOTAL PB CONCENTRATIONS IN SURFACE SOIL NITROGLYCERINE POND AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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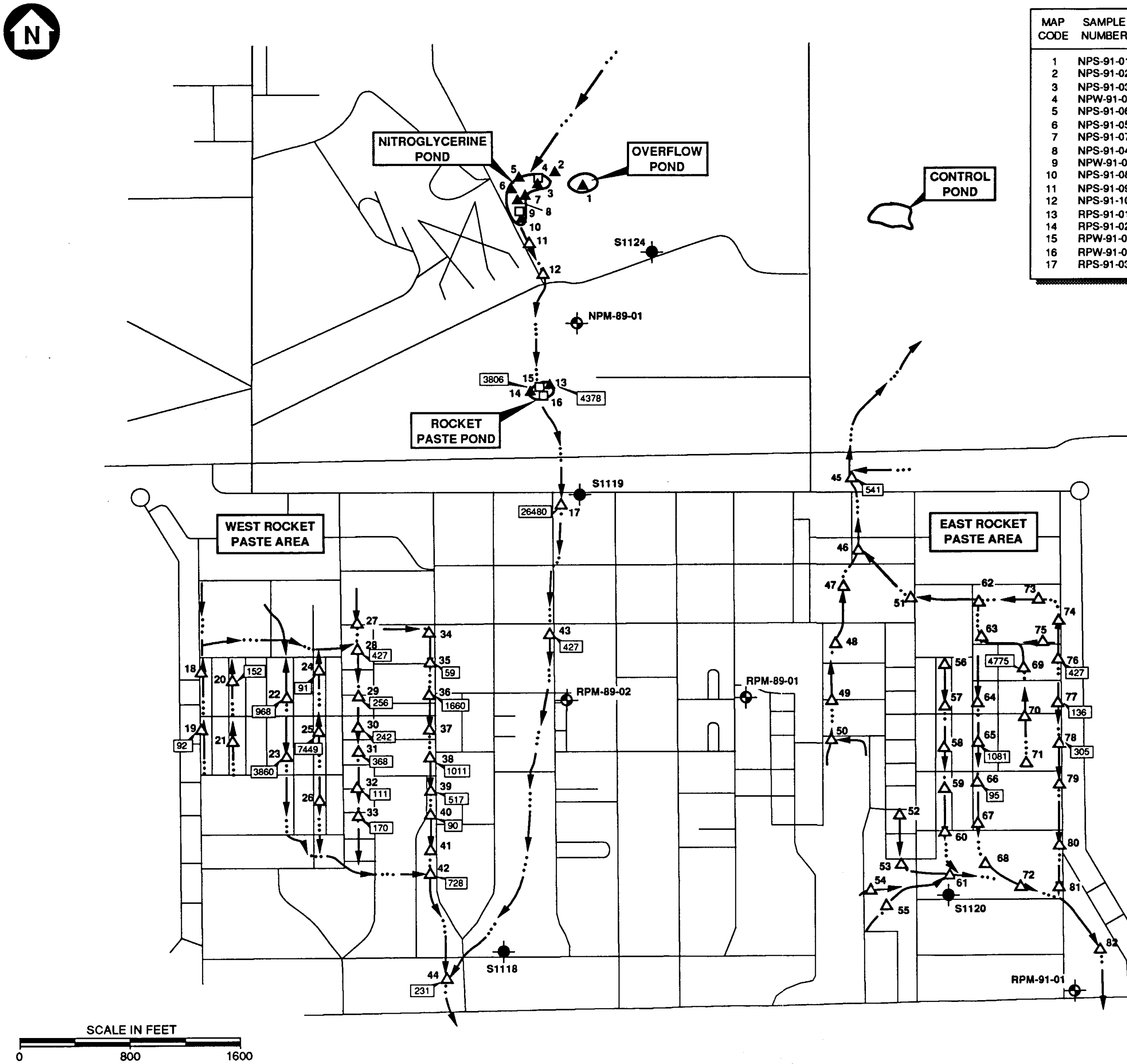

MAP CODE	SAMPLE NUMBER	MAP CODE	SAMPLE NUMBER	MAP CODE	SAMPLE NUMBER	MAP CODE	SAMPLE NUMBER	MAP CODE	SAMPLE NUMBER
1	NPS-91-01	18	RPS-91-34	35	RPS-91-17	52	RPS-91-60	69	RPS-91-12
2	NPS-91-02	19	RPS-91-35	36	RPS-91-18	53	RPS-91-61	70	RPS-91-45
3	NPS-91-03	20	RPS-91-32	37	RPS-91-19	54	RPS-91-62	71	RPS-91-46
4	NPW-91-02	21	RPS-91-33	38	RPS-91-06	55	RPS-91-63	72	RPS-91-47
5	NPS-91-06	22	RPS-91-30	39	RPS-91-20	56	RPS-91-55	73	RPS-91-36
6	NPS-91-05	23	RPS-91-31	40	RPS-91-21	57	RPS-91-56	74	RPS-91-37
7	NPS-91-07	24	RPS-91-28	41	RPS-91-22	58	RPS-91-57	75	RPS-91-44
8	NPS-91-04	25	RPS-91-10	42	RPS-91-07	59	RPS-91-14	76	RPS-91-38
9	NPW-91-01	26	RPS-91-29	43	RPS-91-04	60	RPS-91-58	77	RPS-91-39
10	NPS-91-08	27	RPS-91-08	44	RPS-91-16	61	RPS-91-59	78	RPS-91-40
11	NPS-91-09	28	RPS-91-23	45	RPS-91-11	62	RPS-91-48	79	RPS-91-41
12	NPS-91-10	29	RPS-91-24	46	RPS-91-64	63	RPS-91-49	80	RPS-91-42
13	RPS-91-01	30	RPS-91-25	47	RPS-91-65	64	RPS-91-50	81	RPS-91-43
14	RPS-91-02	31	RPS-91-09	48	RPS-91-66	65	RPS-91-13	82	RPS-91-15
15	RPW-91-01	32	RPS-91-26	49	RPS-91-67	66	RPS-91-51		
16	RPW-91-02	33	RPS-91-27	50	RPS-91-68	67	RPS-91-52		
17	RPS-91-03	34	RPS-91-05	51	RPS-91-54	68	RPS-91-53		

LEGEND

- PAVED ROAD OR TRAMWAY
- DRAINAGE DITCH
- S1119 EXISTING MONITORING WELLS
- RPM-89-02 NEW MONITORING WELLS
- SEDIMENT SAMPLE
- SURFACE SOIL SAMPLE
- SURFACE WATER SAMPLE
- 91 PB CONCENTRATION IN EXTRACTED SAMPLE (µg/L). REGULATORY LEVEL IS 5,000 µg/L (5 mg/L).

NOTE:
1. SEE RI REPORT FOR CHEMICAL DATA SUMMARY (ABB-ES, 1993a).

FIGURE 5-8
TCLP PB CONCENTRATIONS IN SURFACE SOIL NITROGLYCERINE POND AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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Table 6-1
Human Health Contaminants of Concern
Final Creek, Settling Ponds and Spoils Disposal Area

Feasibility Study
Badger Army Ammunition Plant

Compound of Concern	Exposure Point Concentration* - (µg/g)														
	Final Creek Outflow		Final Creek	Settling Pond 1		Settling Pond 2		Settling Pond 3		Settling Pond 4	Spoils Disposal Area 1	Spoils Disposal Area 2	Spoils Disposal Area 3	Spoils Disposal Area 4	Spoils Disposal Area 5
	Sur.	Sub.	Sur.	Sur.	Sub.	Sur.	Sub.	Sur.	Sub.	Sur.	Sur.	Sur.	Sur.	Sur.	Sur.
24DNT	--	--	6	172	17.1	7.6	0.04	2.6	0.057	--	12	1.3	1.1	0.7	--
26DNT	--	--	40	26	--	--	--	1.5	--	--	1	--	--	--	--
2NNDPA	--	--	2	0.97	--	--	--	--	--	--	--	--	--	--	--
AL	--	--	--	--	--	--	--	--	--	60,000	--	--	--	--	--
ANAPYL	0.166	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B2EHP	1.02	--	--	--	--	--	--	--	--	--	0.35	--	--	0.32	--
BAANTR	0.185	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BBFANT	0.723	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BGHIPY	0.618	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BKFANT	0.635	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BR	--	--	--	--	--	--	--	--	--	--	12	4	--	--	16
CH2CL2	--	--	--	--	--	--	--	--	--	--	0.034	0.024	0.025	0.038	0.026
CHRY	0.264	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CL	--	--	--	--	--	--	--	--	--	--	19	23	17	13	18
DEP	--	--	0.13	460	1,340	135	--	44	--	--	--	--	--	--	--
DNOP	--	--	26	14	--	0.74	--	17.4	--	--	51	5.8	4	4.4	6.5
DNDP	--	--	--	--	--	--	--	--	--	--	8.6	--	--	0.63	0.2
DPA	--	--	15	10	--	1.5	--	2.8	--	--	24	3.2	2.2	1.1	2.4
FANT	0.407	--	--	--	--	--	--	--	--	--	--	--	--	--	--

continued

TABLE 6-1
HUMAN HEALTH CONTAMINANTS OF CONCERN
FINAL CREEK, SETTLING PONDS AND SPOILS DISPOSAL AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND OF CONCERN	EXPOSURE POINT CONCENTRATION* - (µg/g)														
	FINAL CREEK OUTFLOW		FINAL CREEK	SETTLING POND 1		SETTLING POND 2		SETTLING POND 3		SETTLING POND 4	SPOILS DISPOSAL AREA 1	SPOILS DISPOSAL AREA 2	SPOILS DISPOSAL AREA 3	SPOILS DISPOSAL AREA 4	SPOILS DISPOSAL AREA 5
	SUR.	SUB.	SUR.	SUR.	SUB.	SUR.	SUB.	SUR.	SUB.	SUR.	SUR.	SUR.	SUR.	SUR.	SUR.
HG	0.505	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NC	--	--	740	60,000	--	280	--	190	0.17	1,038	11,000	8,000	3,800	3,000	11,000
NG	--	--	--	--	--	--	--	--	--	--	19	--	--	--	--
NH3	--	--	1,800	740	--	840	--	520	--	960	--	--	--	--	--
NIT	3.53	3.76	11	13	--	43	--	4.9	--	10	16	10	22	12	18
PB	--	--	40	180	--	250	--	--	--	300	349	373	67	120	102
PHANTR	0.173	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PYR	0.487	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SN	--	--	63	57	--	53	4.7	72	3.9	77	3.68	4.04	5.8	1.64	1.94
SO4	18.2	35.8	260	2,500	--	64	20.2	36	15.2	400	146	130	75	139	38
ZN	--	--	--	--	--	--	--	--	--	--	212	748	251	204	306

Notes:

* Exposure point concentration is the maximum concentration detected
Subsurface data available only for Final Creek Outflow, Settling Pond 1, Settling Pond 2, and Settling Pond 3.
-- = not identified as compound of concern
µg/g = micrograms per gram; equivalent to parts per million (ppm)
Sur. = Surface
Sub. = Subsurface

Table 6-2
Clean-up Standards
Final Creek and Settling Ponds

Feasibility Study
Badger Army Ammunitions Plant

Compound	Soils	
	Protection of Groundwater[1] (mg/kg)	Protection of Human Health[2] (mg/kg)
Organics		
24DNT	0.0033	4.29
26DNT	47.763	4.29
2NNDPA	-	NHD
ANAPYL	-	41.720
B2EHP	420,000	208.57
BGHIPY	-	41,720
DEP	-	834,400
DNOP	-	20,860
DPA	-	NHD
FANT	-	41,720
NC	-	NHD
PHANTR	-	41,720
PYR	-	31,290
CPAH[3]	-	0.4
Metals		
AL	-	NHD
PB	0.688	500
SN	-	625,800
HG	NLD	312.5

Notes:

NHD = no human toxicity data
NLD = no leachate data for modeling
\- = not a human health contaminant of concern
[1]Protective of groundwater per proposed Chapter NR 720.
[2]Protective of human health per proposed Chapter NR 720.
[3]Carcinogenic PAHs; consisting of BAANTR, BBFANT, BKFANT, and CHRY.

TABLE 6-3
CLEAN-UP STANDARDS
SPOILS DISPOSAL AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITIONS PLANT

COMPOUND	SOILS	
	PROTECTION OF GROUNDWATER[1] (mg/kg)	PROTECTION OF HUMAN HEALTH[2] (mg/kg)
Organics		
24DNT	0.0092	4.29
26DNT	134.012	4.29
B2EHP	NI	208.57
CH2CL2	-	389.05
DNOP	-	20,860
DNBP	-	20,860
DPA	-	NHD
NC	-	NHD
NG	-	NHD
Metals		
PB	1.948	500
SN	-	625,800
ZN	156	312,900

Notes:

NHD = no human toxicity data
NI = no impact on groundwater
\- = not a human health contaminant of concern
[1]Protective of groundwater per proposed Chapter NR 720.
[2]Protective of human health per proposed Chapter NR 720.

TABLE 6-4
ECOLOGICAL CONTAMINANTS OF CONCERN
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

	Exposure Point Concentration* - (µg/g)									
Compound of Concern	Final Creek	Settling Pond 1	Settling Pond 2	Settling Pond 3	Settling Pond 4	Spoils Disposal Area 1	Spoils Disposal Area 2	Spoils Disposal Area 3	Spoils Disposal Area 4	Spoils Disposal Area 5
24DNT	6	172	7.6	2.6	--	12	1.3	1.1	0.7	--
26DNT	40	26	--	1.5	--	1	--	--	--	--
2NNDPA	2	0.97	--	--	--	--	--	--	--	--
AL	--	--	--	--	60,000	--	--	--	--	--
B2EHP	--	--	--	--	--	0.35	--	--	0.32	--
BR	--	--	--	--	--	12	4	--	--	16
CH2CL2	--	--	--	--	--	0.034	0.024	0.025	0.038	0.026
CL	--	--	--	--	--	19	23	17	13	18
DEP	0.13	460	135	44	--	--	--	--	--	--
DNBP	26	14	0.74	17.4	--	51	5.8	4	4.4	6.5
DNOP	--	--	--	--	--	8.6	--	--	0.63	0.2
DPA	15	10	1.5	2.8	0.36	24	3.2	2.2	1.1	2.4
NC	740	60,000	280	190	1,038	11,000	8,000	3,800	3,000	11,000
NG	--	--	--	--	--	19	--	--	--	--
NH3	1,800	740	840	520	960	--	--	--	--	--
NIT	11	13	43	4.9	10	16	10	22	12	18
PB	40	180	250	--	300	349	373	67	120	102

Table 6-4
Ecological Contaminants of Concern
Final Creek, Settling Ponds, and Spoils Disposal Area Soil

Feasibility Study
Badger Army Ammunition Plant

	Exposure Point Concentration* - (µg/g)									
Compound of Concern	Final Creek	Settling Pond 1	Settling Pond 2	Settling Pond 3	Settling Pond 4	Spoils Disposal Area 1	Spoils Disposal Area 2	Spoils Disposal Area 3	Spoils Disposal Area 4	Spoils Disposal Area 5
SN	63	57	53	72	77	3.68	4.04	5.8	1.64	1.94
SO4	260	2,500	64	36	400	146	130	75	139	38
ZN	--	--	--	--	--	212	748	251	204	306

Notes:

* Exposure point concentration is the maximum concentration detected
Subsurface data available only for Final Creek Outflow, Settling Pond 1, Settling Pond 2, and Settling Pond 3.
-- = not identified as compound of concern
µg/g = micrograms per gram; equivalent to parts per million (ppm)
Sur. = Surface
Sub. = Subsurface

Table 6-5
Summary of Risk Evaluation for Terrestrial Receptors
Final Creek, Settling Ponds, and Spoils Disposal Area Soil

Feasibility Study
Badger Army Ammunition Plant

	Hazard Indices[A]	
Receptor	**Acute Risk[B]**	**Chronic Risk[C]**
Final Creek Area		
Short-tailed shrew	8.0E+01	2.6E+03
Eastern meadowlark	2.0E+00	2.8E+00
Garter snake	3.9E+00	5.1E+01
Red fox	5.1E-1	2.2E-1
Red-tailed hawk	5.5E-01	2.4E-02
Settling Pond 1 Area		
Short-tailed shrew	3.5E+02	7.8E+03
Eastern meadowlark	8.3E+00	2.4E+01
Garter snake	1.7E+01	3.9E+02
Red fox	2.3E+00	3.8E+00
Red-tailed hawk	2.0E+00	7.5E-01
Settling Pond 2 Area		
Short-tailed shrew	4.7E+02	1.0E+04
Eastern meadowlark	1.1E+01	3.2E+01
Garter snake	2.4E+01	5.1E+-01
Red fox	6.6E-01	8.5E-01
Red-tailed hawk	1.9E+00	2.6E-01
Settling Pond 3 Area		
Short-tailed shrew	6.8E+01	2.5E+03
Eastern meadowlark	1.7E+00	6.4E+00
Garter snake	3.4E+00	1.3E+02
Red fox	2.0E-01	3.5E+00
Red-tailed hawk	5.5E-01	2.7E-01
Settling Pond 4 Area		
Short-tailed shrew	6.7E+02	1.4E+04
Eastern meadowlark	2.0E+01	1.0E+02
Garter snake	3.3E+01	6.8E+02
Red fox	3.5E+00	5.6E+00
Red-tailed hawk	1.1E+01	4.6E+00
Spoils Disposal Site 1 Area		
Short-tailed shrew	6.6E+02	1.3E+04
Eastern meadowlark	1.5E+01	4.3E+01
Garter snake	3.3E+01	6.63+02
Red fox	1.7E+00	2.5E-01
Red-tailed hawk	5.5E+00	3.3E-01
Spoils Disposal 2 Area		
Short-tailed shrew	7.2E+02	1.4E+04
Eastern meadowlark	1.7E+01	3.4E+01
Garter snake	3.6E+01	4.9E+02

continued

TABLE 6-5
SUMMARY OF RISK EVALUATION FOR TERRESTRIAL RECEPTORS
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

	HAZARD INDICES[A]	
RECEPTOR	ACUTE RISK[B]	CHRONIC RISK[C]
Red fox	3.1E+00	2.3E-01
Red-tailed hawk	1.1E+01	3.5E-01
Spoils Disposal 3 Area		
Short-tailed shrew	1.3E+2	2.6E+03
Eastern meadowlark	3.3E+00	5.7E+00
Garter snake	6.7E+00	7.9E+01
Red fox	8.7E-01	7.2E-02
Red-tailed hawk	3.2E+00	7.7E-02
Spoils Disposal 4 Area		
Short-tailed shrew	2.3E+02	4.6E+03
Eastern meadowlark	5.5E+00	1.5E+01
Garter snake	1.2E+01	2.3E+02
Red fox	1.1E+00	1.2E-01
Red-tailed hawk	3.8E+00	1.7E-01
Spoils Disposal 5 Area		
Short-tailed shrew	2.0E+02	3.9E+03
Eastern meadowlark	4.9E+00	1.4E+01
Garter snake	1.0E+01	1.9E+02
Red fox	1.4E+00	1.4E-01
Red-tailed hawk	5.2E+00	2.1E-01

Notes:

A Sum of the individual Hazard Quotients (HQs) for each surface soil contaminant of concern; each HQ calculated by dividing the estimated exposure dosage by the Reference Toxicity Value (RTV). Hazard Quotients are presented in Appendix R of the Final RI Report, Tables R-33 through R-52.
B Based on comparison to acute RTVs.
C Based on comparison to chronic RTVs.

TABLE 6-6
SOIL REMEDIATION GOALS
FINAL CREEK AND SETTLING PONDS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	(1) DETECTION LIMIT (mg/kg)	(2) MAXIMUM DETECTED CONCENTRATION (mg/kg)	(3) MAXIMUM BACKGROUND CONCENTRATION (mg/kg)	(4) PROTECTION OF GROUNDWATER SOIL TARGET CONCENTRATION (mg/kg)	(5) PROTECTION OF HUMAN HEALTH (mg/kg)	(6) PROTECTION OF ECOLOGICAL RECEPTORS (mg/kg)	(7) REMEDIATION GOAL (mg/kg)
Organics							
24DNT	2.5	172	-	0.0033	4.29	NR	2.5[1]
26DNT	2.0	40	-	47.763	4.29	NR	4.29[2]
2NNDPA	0.05	2	-	-	NHD	NR	-
ANAPYL	0.033	1.66	-	-	41.720	NR	NA
B2EHP	0.48	1.02	-	420,000	208.57	NR	NA
CPAH[5]	-	1.81	-	-	0.4	NR	0.4[2]
BGHIPY	0.18	0.618	-	-	41,720	NR	NA
DEP	0.24	1,340	-	-	834,400	20	20[3]
DNOP	0.23	26	-	-	20,860	NR	NA
DPA	0.05	15	-	-	NHD	3.5	3.5[3]
FANT	0.032	0.407	-	-	41,720	NR	NA
NC	50.00	60,000	-	-	NHD	NR	-
PHANTR	0.032	0.173	-	-	41,720	NR	NA
PYR	0.083	0.487	-	-	31,290	NR	NA

continued

Table 6-6
Soil Remediation Goals
Final Creek and Settling Ponds

Feasibility Study
Badger Army Ammunition Plant

Compound	(1) Detection Limit (mg/kg)	(2) Maximum Detected Concentration (mg/kg)	(3) Maximum Background Concentration (mg/kg)	(4) Protection of Groundwater Soil Target Concentration (mg/kg)	(5) Protection of Human Health (mg/kg)	(6) Protection of Ecological Receptors (mg/kg)	(7) Remediation Goal (mg/kg)
Organics							
Metals							
AL	5.0	60,000	50,000	-	NHD	19	50,000[4]
HG	0.1	0.505	0.38	NLD	312.5	NR	NA
PB	0.434	300	30	0.688	500	0.0013	30[4]
SN		77	10	-	625,800	0.011	10[4]

Notes:

mg/kg = milligrams per kilogram
NR = Negligible risk to ecological receptors.
NA = Not applicable; protective concentrations are greater than maximum detected concentration.
NHD = No human toxicity data.
NLD = No leaching data for modeling.
1 Detection limit
2 Protective of human health per NR 720 Rule.
3 Protective of ecological receptors.
4 Background concentration; which is greater than NR 720 concentration for protection of groundwater and/or ecological risk concentration.
5 Carcinogenic PAHs; consisting of BAANTR, BBFANT, BKFANT, and CHRY.

TABLE 6-7
SOIL REMEDIATION GOALS
SPOILS DISPOSAL AREAS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	(1) DETECTION LIMIT (mg/kg)	(2) MAXIMUM DETECTED CONCENTRATION (mg/kg)	(3) MAXIMUM BACKGROUND CONCENTRATION (mg/kg)	(4) PROTECTION OF GROUNDWATER SOIL TARGET CONCENTRATION (mg/kg)	(5) PROTECTION OF HUMAN HEALTH (mg/kg)	(6) PROTECTION OF ECOLOGICAL RECEPTORS (mg/kg)	(7) REMEDIATION GOAL (mg/kg)
Organics							
24DNT	2.5	12	-	0.0092	4.29	NR	2.5[1]
26DNT	2.0	1	-	134.012	4.29	NR	NA
B2EHP	0.48	0.35	-	NI	208.57	NR	NA
CH2CL2	0.005	0.038	-		389.05	NR	NA
DNOP	0.23	51	-		20,860	NR	NA
DNBP	1.3	8.6	-			NR	-
DPA	0.05	24	-			3.5	3.5[2]
NC	50.00	11,000	-			NR	-
NG	0.51	19	-			3.6	3.6[2]

continued

TABLE 6-7
SOIL REMEDIATION GOALS
SPOILS DISPOSAL AREAS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	(1) DETECTION LIMIT (mg/kg)	(2) MAXIMUM DETECTED CONCENTRATION (mg/kg)	(3) MAXIMUM BACKGROUND CONCENTRATION (mg/kg)	(4) PROTECTION OF GROUNDWATER SOIL TARGET CONCENTRATION (mg/kg)	(5) PROTECTION OF HUMAN HEALTH (mg/kg)	(6) PROTECTION OF ECOLOGICAL RECEPTORS (mg/kg)	(7) REMEDIATION GOAL (mg/kg)
Organics							
Metals							
PB	0.434	373	30	1,948	500	0.0053-0.0089	30[3]
SN	20.0	5.8	10		625,800	NL	NA
ZN	2.34	748	81.3	156	312,900	2.5-4.2	81.3[3]

Notes:

mg/kg = milligrams per kilogram
NI = No impact on groundwater
NR = Negligible risk to ecological receptors
NHD = No human toxicity data
NA = Not applicable; protective concentrations are greater than maximum detected concentration
[1] Detection limit
[2] Protective of ecological receptors
[3] Background concentration; which is greater than NR 720 concentration for protection of groundwater and/or ecological risk concentration

TABLE 6-8
GENERAL RESPONSE ACTIONS AND POTENTIAL REMEDIAL TECHNOLOGIES
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GENERAL RESPONSE ACTION	SOIL TECHNOLOGY	DESCRIPTION
No Action	None (No Action)	No action. Site monitoring.
Minimal Action	Institutional Controls/ Education Programs/ Site Fencing	Zoning and deed restrictions on potentially contaminated areas. Educate public concerning site hazards. Erect physical barriers to site access.
Containment	Soil Cover	A layer of native soil is placed over the site that is sufficiently thick to prevent direct contact and ingestion hazards associated with contaminated surface soil.
	Capping	Low-permeability cover (e.g., clay and soil; asphalt; clay and synthetic membrane covered with soil) is constructed over the site to provide a barrier to water infiltration and/or to prevent direct contact and ingestion hazards associated with contact of contaminated surface soil.
Excavation/Disposal	On-Site Landfill	Soil not regulated by RCRA Land Disposal Restrictions is excavated and disposed of in a secure on-site landfill constructed for that purpose.
	Off-Site Landfill	Soil not regulated by RCRA Land Disposal Restrictions is excavated, transported, and disposed of in a secure, existing landfill.
Soil Excavation/Treatment	On-Site Incineration	Soil is excavated and treated with a mobile incinerator which thermally destroys VOCs/SVOCs in a direct fired treatment unit.
	Off-Site Incineration	Soil is excavated and transported to a licensed incinerator which thermally destroys VOCs/SVOCs in a direct-fired treatment unit.
	Solvent Extraction	Soil is excavated and mixed with a chemical solvent in a batch mixer. Soil settles out and solvent/contaminant is decanted off. The contaminant is then separated from the solvent to produce an effluent stream of concentrated contaminant.

continued

TABLE 6-8
GENERAL RESPONSE ACTIONS AND POTENTIAL REMEDIAL TECHNOLOGIES
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GENERAL RESPONSE ACTION	SOIL TECHNOLOGY	DESCRIPTION
Soil Excavation/Treatment (cont.)	Ex-situ Stabilization/Solidification	Soil is excavated and mixed with a setting agent (e.g., cement, fly ash, lime) to form a monolithic or granular product in which contaminants are entrapped by the solidified mass.
	Anaerobic Thermal Process	Soil is excavated and treated by a mobile unit which uses high temperatures in an anaerobic environment to desorb VOCs/ SVOCs from the soil. The contaminants are condensed into a liquid waste stream.
	Biodegradation/Composting	Soil is excavated and bulking agents (e.g., wood chips) are added; the piles are periodically turned over to facilitate aerobic and anaerobic decomposition of VOCs/SVOCs.
	Soil Washing	Soil is excavated and mixed with an aqueous-based washing solution in a series of high-energy mobile washing units. VOCs/SVOCs and metals can be separated from soil. Washing solution is recycled.
	Vitrification Thermal Process	Soil is excavated and treated in a reactor which heats soil to its melting point, then allows it to cool into solid, glass-like structure. VOCs/SVOCs are either trapped in the matrix, destroyed, or volatilized.
In Situ Treatment	In-situ Stabilization/Solidification	A setting agent is added in place to contaminated soil to form a monolithic or granular product in which contaminants are entrapped within a solidified mass.
	Vitrification	High voltage current is passed through the contaminated zone until complete meltdown of soils has occurred. The high temperatures generated during meltdown pyrolyze and eventually combust VOCs/SVOCs.

continued

TABLE 6-8
GENERAL RESPONSE ACTIONS AND POTENTIAL REMEDIAL TECHNOLOGIES
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GENERAL RESPONSE ACTION	SOIL TECHNOLOGY	DESCRIPTION
	Soil Flushing	Aqueous-based washing solution is applied at the ground surface. Contaminants are removed from soil particles and held in the liquid phase as the solution infiltrates the soil. Solution containing the contaminants is removed through extraction wells after reaching the water table.

Notes:

RCRA = Resource Conservation and Recovery Act

TABLE 6-9
REMEDIAL TECHNOLOGY SCREENING
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
No Action	• Easily implemented. • No costs would be incurred with this option other than for monitoring.	• Does not reduce exposure potential for human or environmental receptors. • Would not reduce mobility, toxicity, or volume of contaminants.	Eliminated	Not protective of human health or the environment.
Institutional Controls/ Education Programs	• Reduces exposure potential for human receptors. • Easily implemented. • Low potential for exposure to contaminants during implementation. • Minimal impact to environment during implementation.	• Would not reduce mobility, toxicity, or volume of contaminants. • Long-term monitoring and maintenance would be required. • Long-term liability associated with waste.	Retained	Would reduce the potential for direct contact and ingestion by human receptors.

continued

TABLE 6-9
REMEDIAL TECHNOLOGY SCREENING
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Soil Cover	• Reduces exposure potential for human and environmental receptors. • Not subject to RCRA Land Disposal Restrictions. • Easily implemented. • Cover soil can be selected and grading designed to reduce infiltration of surface water through contaminated soil.	• Would not reduce mobility, toxicity, or volume of contaminants. • Would not reduce mobility of contaminants resulting from infiltration of precipitation, and would not be protective of groundwater. • Uncertain design life. • Long-term monitoring and maintenance would be required. • Long-term liability associated with waste.	Retained	Soil cover would reduce direct contact and ingestion hazards associated with exposure to surface soil, and could reduce infiltration water.

continued

TABLE 6-9
REMEDIAL TECHNOLOGY SCREENING
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Capping	• Reduces exposure potential for human and environmental receptors. • No secondary wastes produced. • Commonly used method for remediation. • Significantly reduces potential for contaminant mobility.	• Would not reduce toxicity, or volume of contaminants. • Complete containment of contaminants not provided. • Uncertain design life. • Long-term monitoring and maintenance would be required. • Long-term liability associated with waste.	Retained	Cap would meet remediation goals.

continued

TABLE 6-9
REMEDIAL TECHNOLOGY SCREENING
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
On-Site Landfill	• No secondary wastes produced. • Contaminants may be relocated to a more stable, contained, lower exposure potential environment. • No transportation of waste over public roads. • Experienced excavation contractors available.	• Would not reduce toxicity, or volume of contaminants. • RCRA Land Disposal Restrictions may limit wastes eligible for disposal. • Long-term monitoring and maintenance would be required. • Long-term liability associated with landfilled waste.	Eliminated	Obtaining regulatory approval for a special waste landfill at BAAP would likely be difficult due to site geology (i.e., sandy soils) overlying an aquifer used as a drinking water source.

continued

TABLE 6-9
REMEDIAL TECHNOLOGY SCREENING
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Off-Site Landfill	• Widely used and easily implemented technology. • No wastes/treatment residuals remaining on site. • Contaminants may be relocated to a more stable, contained, lower exposure potential environment. • Relatively little mobilization effort and cost. • Experienced excavation contractors available.	• Would not reduce toxicity or volume of contaminants. • RCRA Land Disposal Restrictions may limit wastes eligible for disposal. • Limited landfill capacity nationwide. • Transportation and landfilling costs may be expensive. • Long-term liability associated with landfilled wastes.	Retained	Could be used for direct disposal of soils or as an option for disposal of treatment residuals.
On-Site Incineration	• Destruction and removal efficiencies of greater than 99.99% for organics, thus reducing volume of contaminants. • Widely used and demonstrated for treating organics at full-scale. • Mobile units are available.	• Treatment of metals collected by air pollution equipment may be required. • Trial burns would be required to receive permits to operate. • Treatment of metals remaining in the soil may be required.	Eliminated	Not capable of treating metals.

continued

TABLE 6-9
REMEDIAL TECHNOLOGY SCREENING
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Off-Site Incineration	• Destruction and removal efficiencies of greater than 99.99%, thus reducing volume of contaminants. • Widely used and demonstrated for treating organics at full-scale. • No long-term monitoring or maintenance required. • Experienced vendors are available.	• Treatment of metals remaining in soil may be required. • Limited capacity at RCRA-permitted incinerators. • High cost associated with transportation and incineration of wastes.	Eliminated	Not capable of treating metals.

continued

TABLE 6-9
REMEDIAL TECHNOLOGY SCREENING
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Solvent Extraction	• Contaminants are transferred into a manageable liquid waste stream. • Capability for treating soils contaminated with VOCs/SVOCs and metals. • Demonstrated full-scale performance for removal of VOCs/SVOCs from sludge.	• Would not reduce mobility, toxicity, or volume of contaminants. • Concentrated contaminant waste stream requires further treatment. • Limited operating experience with BAAP-specific contaminated soils. • Depending on process, residual extraction solvent may remain in soil and would require treatment. • Treatability studies required to determine potential for treating soil contaminated with inorganics (especially metals).	Eliminated	Solvent extraction has been demonstrated primarily on sludges; there is very little experience with contaminated soils. This technology would not offer significant advantage over other proven technologies.

continued

TABLE 6-9
REMEDIAL TECHNOLOGY SCREENING
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Ex-situ Stabilization/ Solidification	• Reduces mobility of contaminants. • Technology is relatively simple and easily implemented. • Technology is reliable and has been demonstrated at full-scale for treating VOCs/ SVOCs and metals. • Experienced vendors are available.	• Would not reduce toxicity or volume of contaminants. • Volume of contaminated media potentially increased by 20-30%. • Pre-treatment for VOCs/SVOCs potentially required. • Treatment is potentially reversible and, therefore, long-term performance not demonstrated. • Treatability studies would be required. • High concentrations of VOCs/ SVOCs may interfere with the setting agent.	Retained	Technology demonstrated for treatment of metals.

continued

TABLE 6-9
REMEDIAL TECHNOLOGY SCREENING
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Anaerobic Thermal Process	• Contaminants are transferred into a manageable liquid waste stream. • May not require an incinerator permit to operate. • Demonstrated full-scale performance for removal of VOCs/SVOCs from soil.	• Concentrated contaminant waste stream requires further treatment. • Treatment of metals remaining in soil required. • Treatment of metals collected by air pollution control equipment potentially required. • Limited number of transportable units available. • Treatability studies would be required.	Eliminated	Not capable of effectively treating soil contaminated with metals.

continued

TABLE 6-9
REMEDIAL TECHNOLOGY SCREENING
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Biodegradation/ Composting	• Would reduce mobility, toxicity, and volume of contaminants. • Demonstrated performance for treating nitrocellulose contaminated sediment during treatability and field studies at BAAP. • Composting materials are readily available. • Widely used for treatment of petroleum wastes and sludge from municipal sewage treatment plants.	• Treatment of leachate may be required. • Metals are not effectively treated by biodegradation.	Eliminated	Not applicable to metals applications.

continued

TABLE 6-9
REMEDIAL TECHNOLOGY SCREENING
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Soil Washing	• Wide application to varied waste groups. • Demonstrated at full-scale for removal of VOCs/ SVOCs and metals from soil. • Mobile units are available.	• Potentially hazardous chemicals may be brought on site to be used in process. • Concentrated contaminant waste stream requires further treatment. • Potential difficulty in removing washing solution from treated soil. • Limited effectiveness for treating soil with high humic content and high fine-grained clay fraction. • Treatability studies would be required to determine potential for treating soils contaminated with metals.	Retained	Capable of treating soil contaminated with both VOCs/SVOCs and metals.

continued

TABLE 6-9
REMEDIAL TECHNOLOGY SCREENING
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Vitrification	• Reduces mobility, toxicity, and volume of VOCs/SVOCs. • Reduces mobility of metals. • Effective for VOCs/ SVOCs and metals.	• Treatment may be required to destroy VOCs in the vapor phase. • Vitrified soil would require disposal. • Would not be effective on soils with high moisture content. • Process is very energy intensive. • Not demonstrated at the full-scale level for hazardous wastes. • Mobile units not available.	Eliminated	Technology not demonstrated at full-scale level for treatment of explosives.

continued

TABLE 6-9
REMEDIAL TECHNOLOGY SCREENING
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
In Situ Stabilization/ Solidification	• Reduces mobility of contaminants. • Technology has been demonstrated at pilot-scale for treating VOCs/ SVOCs and metals. • Not subject to RCRA Land Disposal Restrictions. • Technology is relatively simple and easily implemented. • Experienced vendors are available.	• Would not reduce toxicity, or volume of contaminants. • Treatment is potentially reversible; long-term performance not demonstrated. • Volume of contaminated media increased by 20-30%. • High concentrations of VOCs/SVOCs may interfere with the setting agent. • Reagent/waste ratios are difficult to control. • Not demonstrated at full-scale. • Long-term monitoring of the groundwater would be required. • Treatability studies would be required.	Retained	Technology has been demonstrated at pilot-scale for treatment of metals.

continued

TABLE 6-9
REMEDIAL TECHNOLOGY SCREENING
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
In Situ Vitrification	• Reduces mobility, toxicity, and volume of contaminants. • Effective for VOCs/ SVOCs and metals. • Not subject to RCRA Land Disposal Restrictions.	• Treatment may be required to destroy VOCs in the vapor phase. • Would not be effective on soils with high moisture content. • Process is very energy intensive. • Vendors not currently available. • Long-term groundwater monitoring would be required. • Treatability studies would be required. • Not demonstrated at the full-scale level for hazardous wastes.	Eliminated	Technology not demonstrated at full-scale level for treatment of explosives.

continued

TABLE 6-9
REMEDIAL TECHNOLOGY SCREENING
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Soil Flushing	• Effective for removal of VOCs from permeable soils. • Full-scale units are available. • Not subject to RCRA Land Disposal Restrictions.	• Difficulty in treating complex waste mixtures. • Potential for uncontrolled migration of contaminants to groundwater. • Limited effectiveness for treating soil with high humic content and high fine-grained clay fraction. • Treatability studies would be required.	Eliminated	Should not be considered at a site where groundwater remediation is not planned. Would result in spreading contamination into a previously uncontaminated media (i.e., groundwater).

Notes:

BAAP = Badger Army Ammunition Plant
RCRA = Resource Conservation and Recovery Act
SVOC = Semivolatile Organic Compound
VOC = Volatile Organic Compound

TABLE 6-10
REMEDIAL TECHNOLOGIES RETAINED FOR REMEDIAL ALTERNATIVES DEVELOPMENT
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

MINIMAL ACTION	CONTAINMENT	EXCAVATION/ DISPOSAL	SOIL EXCAVATION/TREATMENT	IN SITU TREATMENT
• Institutional Controls/Education Programs	• Soil Cover • Capping	• Off-site Landfill	• Ex-situ Stabilization/ Solidification • Soil Washing	• In-situ Stabilization/Solidification

TABLE 6-11
IDENTIFICATION OF REMEDIAL ALTERNATIVES
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVES	ACTION						
	MINIMAL ACTION	SOIL COVER	CAPPING	OFF-SITE LANDFILL	SOIL WASHING	EX-SITU STABILIZATION/ SOLIDIFICATION	IN SITU STABILIZATION/ SOLIDIFICATION
Surface Soils							
SSP-SS1	X						
SSP-SS2		X					
SSP-SS3			X				
SSP-SS4				X			
SSP-SS5					X		
SSP-SS6						X	
SSP-SS7		X					X
SSP-SS8				X		X	

Note:

X = Identified technology is a component of alternative.

TABLE 6-12
DEVELOPMENT OF REMEDIAL ALTERNATIVES
SETTLING PONDS AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Remedial Action Objectives:

1) Prevent migration of contaminated soil by soil erosion.

2) Prevent the exposure of terrestrial receptors to surface soil at Final Creek and the Settling Ponds containing concentrations of PB (excluding Settling Pond 3) and SN that pose unacceptable risk.

3) Prevent the exposure to terrestrial receptors to surface soil containing concentrations of DEP (at Settling Ponds 1, 2, and 3) and DPA (at Final Creek and Settling Pond 1) that pose unacceptable risk.

4) Prevent the exposure of terrestrial receptors to surface soil at Settling Pond 4 containing concentrations of AL that pose unacceptable risk.

5) Prevent the exposure of terrestrial receptors to surface soil at the Spoils Disposal Sites containing concentrations of ZN and PB that pose unacceptable risk.

6) Prevent the exposure of terrestrial receptors to surface soil at Spoils Disposal Site 1 containing concentrations of DPA and NG that pose unacceptable risk.

7) Prevent the exposure of human receptors to soil at Final Creek and the Settling Ponds containing concentrations of 24DNT, 26DNT, and CPAH that pose unacceptable risk.

8) Prevent the exposure of human receptors to soil at the Spoils Disposal Sites containing concentrations of 24DNT that pose unacceptable risks.

9) Prevent concentrations of 24DNT and PB in soil at Final Creek and the Settling Ponds which exceed cleanup standards for protection of groundwater (developed from the proposed Chapter NR 720) from degrading groundwater quality in excess of WPALs.

10) Prevent concentrations of 24DNT, PB, and ZN in soil at the Spoils Disposal sites which exceed cleanup standards for protection of groundwater (developed from the proposed Chapter NR 720) from degrading groundwater quality in excess of WPALs.

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
SSP-SS1: Minimal Action	• Institutional Controls. Implement zoning and deed restrictions to restrict or prohibit future residential use of the site. • Education programs. • Five-year site reviews.
SSP-SS2: Soil Cover	• Installation of a 2-foot minimum soil cover plus subgrade fill for grading purposes to prevent direct contact or incidental ingestion by ecological or human receptors. • Surface water management to minimize erosion of cover system. • Post-closure plan development to monitor, maintain, and inspect site.

continued

TABLE 6-12
DEVELOPMENT OF REMEDIAL ALTERNATIVES
SETTLING PONDS AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
SSP-SS2: Soil Cover (continued)	• Institutional controls. Implement zoning and deed restrictions to protect the soil cover from invasive activities. • Five-year site reviews.
SSP-SS3: Capping	• Very low permeability components of caps (i.e., geomembrane and clay) significantly reduce leaching of contaminants to groundwater. • Surface water management to minimize erosion of cover system. • Post-closure plan development to monitor, maintain, and inspect site. • Institutional controls. Implement zoning and deed restrictions to protect the caps from invasive activities. • Five year site review.
SSP-SS4: Off-Site Landfill	• Excavate contaminated soil. • Confirmatory sampling to confirm wastes have been removed. • Backfill excavation with clean fill. • Sample and analyze excavated soil to establish that it meets landfill acceptable criteria. • Transport soil to off-site landfill.

continued

TABLE 6-12
DEVELOPMENT OF REMEDIAL ALTERNATIVES
SETTLING PONDS AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
SSP-SS5: Soil Washing	• Mobilize soil washing equipment to site. • Excavate contaminated soil. • Confirmatory sampling to confirm wastes have been removed. • Transport and stockpile wastes at treatment area. • Wash contaminated soil. • Transport secondary waste streams off site for treatment. • Backfill excavations with treated soil.
SSP-SS6: Ex-situ Stabilization/Solidification, Soil Cover	• Excavate contaminated soils. • Confirmatory sampling to confirm wastes have been removed. • Transport and stockpile wastes at treatment area. • Stabilize/solidify soil. • Transport treated soil mass back to excavations. • Backfill excavations with treated soil mass, and place soil cover, plus subgrade fill for grading purposes.
SSP-SS7: Modified In-Situ Stabilization/ Solidification, Soil Cover	• Mobilize in-situ stabilization equipment to the site. • Excavate contaminated subsurface soils (Settling Pond 1) and stockpile on site. • Backfill excavation with clean cover soil plus additional fill for grading purposes. • Stabilize/solidify contaminated surface soil in-situ. • Spread excavated contaminated soil over treated surface soil. • Stabilize/solidify excavated contaminated soil using in-situ equipment. • Confirmatory sampling to ensure contaminated soil has been stabilized. • Cover treated area with clean cover soil plus additional fill for grading purposes. • Post-closure plan development to monitor, maintain, and inspect site. • Five-year site reviews.

continued

TABLE 6-12
DEVELOPMENT OF REMEDIAL ALTERNATIVES
SETTLING PONDS AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
SSP-SS8: Ex-situ Stabilization/Solidification, Off-site Landfill	• Excavate contaminated soils. • Confirmatory sampling to confirm wastes have been removed. • Backfill excavation with clean fill. • Transport and stockpile wastes at treatment area. • Stabilize/Solidify soil. • Transport stabilized soil to off-site landfill.

TABLE 6-13
SCREENING OF REMEDIAL ALTERNATIVES
SETTLING PONDS AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative SSP-SS1: Minimal Action: This alternative consists of institutional controls, educational programs, and five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Low potential for exposure to contaminants during implementation. • Institutional controls would restrict or prohibit future residential use of the site. • Educational programs would increase public awareness about contamination.	Advantages • Would be easy to implement because no remedial actions are required. • Services and material readily available.	Advantages • Cost includes administration of institutional controls, educational programs, and groundwater monitoring and maintenance.
Disadvantages • Would not reduce mobility, toxicity, or volume of contaminants. • Does not achieve remedial action objectives.	Disadvantages • Not consistent with SARA's preference for treatment. • Long-term monitoring and maintenance would be required.	Disadvantages • Remedial actions, if required, may be more costly in the future if contamination migrates. • Long-term liability associated with waste.

CONCLUSION: The minimal action alternative is **retained** as a baseline for comparison with the remaining alternatives at the Settling Ponds and Spoils Disposal Areas.

Note:

SARA = Superfund Amendments and Reauthorization Act

continued

TABLE 6-13
SCREENING OF REMEDIAL ALTERNATIVES
SETTLING PONDS AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative SSP-SS2: Soil Cover: This alternative consists of a soil cover to prevent direct contact and incidental ingestion of contaminated surface soil by ecological and human receptors. This alternative includes five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Soil cover would be effective in reducing contact with contaminated soil by ecological and human receptors. • Not subject to RCRA Land Disposal Restrictions. • Cover soil may be selected (by reducing fines content), and surface graded to reduce leaching of contaminants to groundwater.	Advantages • Would be easy to implement. • Soil cover would require minimal maintenance. • Equipment and supplies readily available.	Advantages • Soil cover costs are relatively low per unit.
Disadvantages • Fails to meet remedial action objectives for protection of groundwater. • Would not reduce the mobility, toxicity, or volume of contaminants. • Soil cover may only be protective for the short term if not properly maintained.	Disadvantages • Would require long-term monitoring and maintenance. • May require future soil treatment. • Approximately 1,000,000 yd^3 of fill would be required.	Disadvantages • Long-term liability associated with waste. • Long-term costs associated with operation and maintenance of cover.

CONCLUSION: Because this alternative does not meet the remedial action objectives developed in accordance with proposed chapter NR 720, it is **eliminated** from further consideration.

Note:

RCRA = Resource Conservation and Recovery Act

continued

TABLE 6-13
SCREENING OF REMEDIAL ALTERNATIVES
SETTLING PONDS AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative SSP-SS3: Capping: This alternative consists of a low hydraulic conductivity cap to prevent direct contact and incidental ingestion of contaminated surface soil by ecological receptors and to significantly reduce infiltration of surface water through waste and subsequent leaching to groundwater. This alternative includes five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Potential for achieving remedial action objectives. • Low potential for exposure to contaminants during implementation. • Capping would be effective in reducing contact with contaminated soil by ecological receptors. • Capping would minimize significantly reduce of contaminants to groundwater. • Not subject to RCRA Land Disposal Restrictions.	Advantages • Would be easy to implement. • Capping would require minimal maintenance. • Equipment, supplies, and vendors are readily available.	Advantages • Capping costs are relatively low per unit.
Disadvantages • Would not reduce the toxicity, or volume of contaminants. • Capping cover may only be protective for the short term if not properly maintained. • RCRA caps may only be protective for the short term.	Disadvantages • Would require long-term monitoring and maintenance. • May require future soil treatment. • Approximately 1,800,000 yd^3 of fill are required. • Several borrow sources must be used to obtain suitable soil. A borrow study must be performed on each source.	Disadvantages • Long-term liability associated with waste. • Long-term costs associated with operation and maintenance of cover.

CONCLUSION: Because this alternative reduces direct contact, would be easily implemented and potentially achieves remedial action objectives, it is **retained** for detailed analysis.

Note: RCRA = Resource Conservation and Recovery Act

continued

TABLE 6-13
SCREENING OF REMEDIAL ALTERNATIVES
SETTLING PONDS AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative SSP-SS4: Off-Site Landfill: This alternative consists of excavating contaminated soil, backfilling excavations with clean fill, and transporting the contaminated soil off site for disposal in a secure landfill.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives. • Disposal of contaminants in a secure landfill. • Eliminates threat to ecological and human receptors at site.	Advantages • Long-term monitoring and maintenance provided by host landfill. • Surface and shallow subsurface soils are easily removed with conventional grading/excavation equipment. • Excavation and transportation services are available. • No post-remediation monitoring or maintenance program required.	Advantages • No long-term costs associated with operation and maintenance of monitoring systems.
Disadvantages • Would not reduce the toxicity, or volume of contaminants. • Excavation would increase the dermal contact risk for on-site workers.	Disadvantages • Contaminated soil may fail TCLP analysis for SN, PB, thus invoking RCRA Land Disposal Restrictions. • Contaminated soil which fails TCLP analysis for NC, PB would be rejected by landfill unless it is first treated. • Approximately 490,000 yd^3 would be transported for disposal. • Capacity at RCRA-permitted landfills may be limited.	Disadvantages • With a volume of 490,000 yd^3, the transportation and landfilling cost for this alternative would be quite expensive. • Long-term liability associated with landfilled wastes.

CONCLUSION: Approximately 490,000 yd^3 are to be remediated at the Settling Ponds and Spoils Disposal Area. Considering that landfill capacity may be limited and the cost for transportation and disposal is very high, this alternative is **eliminated** from further evaluation.

Notes:

RCRA = Resource Conservation and Recovery Act
TCLP = Toxicity Characteristic Leachate Procedure
PB = Lead
SN = Tin

TABLE 6-13
SCREENING OF REMEDIAL ALTERNATIVES
SETTLING PONDS SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative SSP-SS5: Soil Washing: This alternative consists of excavating contaminated soil, washing contaminated soil, and backfilling the excavations with the treated soil.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages	Advantages	Advantages
• Achieves remedial action objectives. • Reduces the volume of contaminated soil. • Threat to ecological receptors is eliminated. • Off-site treatment of contaminated wastestream would reduce mobility of contaminants.	• Soil washing is a proven, reliable technology for treating varied waste groups, including metals. • Soil washing services are available. • No post-remediation monitoring and maintenance provisions. • Surface soils are easily and rapidly removed with conventional excavation/grading equipment.	• No post-remediation operation and maintenance costs. • No long-term liability.
Disadvantages	Disadvantages	Disadvantages
• Would not reduce toxicity or volume of contaminant of concern. • Potential for direct human contact with contaminated soil during soil washing. • Limited effectiveness for soils with high humic content and high fine grained fraction.	• Contaminants may be difficult to remove from fine-grained soils. • Depending on the soil gradation, the secondary waste stream may be a significant percentage of the original volume. • Fine soil particles are difficult to remove from the washing solution. • Treatability study required to determine effectiveness.	• Costs of treating the secondary waste stream could significantly increase overall cost. • Costs to excavate approximately 490,000 yd^3 are high.

CONCLUSION: Because the surface soil at the Settling Ponds and Spoils Disposal Area is topsoil and loess, soil washing may not result in significant contaminant volume reduction. Therefore, this alternative is **eliminated** from further consideration.

continued

TABLE 6-13
SCREENING OF REMEDIAL ALTERNATIVES
SETTLING PONDS AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative SSP-SS6: Ex situ Stabilization/Solidification: This alternative consists of excavating contaminated soil, solidifying it, backfilling it on site, and covering it. Five-year site reviews are included.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives because contaminants in the treated soil are unavailable to receptors and would not leach into groundwater. • Reduces the mobility of contaminants and reduces ingestion risk to ecological receptors. • No significant long-term threat to human health or the environment.	Advantages • Stabilization/Solidification is a proven, reliable technology for the treatment of PB- and SN-contaminated soils. • Vendors are readily available. • Surface and shallow subsurface soils are easily removed with conventional excavation equipment.	Advantages • No transportation and disposal costs. • Soil cover costs are low.
Disadvantages • Excavated soils would increase the dermal contact risk to on-site workers. • Would not reduce toxicity of contaminants. • Volume of contaminated soil increases by 20-30% • Treatment is potentially reversible and landfilling or further treatment required.	Disadvantages • Backfilling areas of excavated surface soil would be difficult if treatment residuals consist of large monolithic blocks. • Confirmatory testing of the final product may be required to confirm that treated soil meets the treatment standards. • Treatability studies would be required to determine reagent mixture.	Disadvantages • Post-remediation costs associated with inspection, monitoring, and maintenance. • Costs to excavate approximately 490,000 yd^3 are high. • If landfilling or further treatment is required, costs will increase significantly.

CONCLUSION: Although solidification is an effective method of treatment for PB- and SN-contaminated soils, this alternative has no advantage over in situ treatment and, because it is actually more costly (with excavation costs), is **eliminated** from detailed analysis.

Notes:

PB = Lead
SN = Tin

continued

TABLE 6-13
SCREENING OF REMEDIAL ALTERNATIVES
SETTLING PONDS AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative SSP-SS7: Modified In Situ Stabilization/Solidification and Soil Cover: This alternative consists of in situ stabilization of contaminated soils and 2 foot minimum soil cover. This alternative would also include five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives because contaminants in the soil are unavailable to receptors and would not leach into groundwater. • Remediation of contaminated soil and soil cover would reduce mobility and eliminate direct contact and incidental soil ingestion hazards by ecological receptors. • In situ treatment provides low potential for direct human contact with contaminants during the remediation process.	Advantages • Stabilization/Solidification is a proven technology for treatment of PB- and SN-contaminated soils. • Vendors are readily available. • Shallow subsurface soils are easily removed with conventional excavation equipment.	Advantages • No transportation and disposal costs. • Soil cover costs are low. • Lower capital costs as compared to ex-situ stabilization.
Disadvantages • Would not reduce toxicity of contaminants in the solidified mass. • Treatment is potentially reversible and landfilling or further treatment required. • Volume of contaminated soil increased by 20-30%. • Excavated soils would increase the dermal risk to on-site workers.	Disadvantages • Confirmatory sampling of the final product may be required to ensure that the solidified mass meets treatment standards. • Would require long-term monitoring and maintenance. • Treatability study would be required to determine the optimal mixture of reagents. • Backfilling areas of excavated surface soil would be difficult if treated soil consists of monolithic blocks. • Would require excavation, stockpiling and ex situ treatment of approximately 232,000 yd^3 of shallow subsurface soil.	Disadvantages • Post-remediation costs. • Long-term liability associated with unexcavated wastes. • If landfilling or further treatment is required, costs will significantly increase.

CONCLUSION: This alternative is **retained** for detailed analysis because stabilization/solidification is a proven technology for the treatment of SN-PB-contaminated soil. In addition, in situ treatment has cost and disposal advantages over ex situ treatment.

Notes:

PB = Lead SN = Tin

TABLE 6-13
SCREENING OF REMEDIAL ALTERNATIVES
SETTLING PONDS AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative SSP-SS8: Ex-Situ Stabilization/Solidification, Off-site Landfill: This alternative consists of excavating contaminated soil, solidifying the soil, transporting the treated soil to an off-site landfill, and backfilling the excavations with clean fill.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives. • Remediation of contaminated soil would reduce mobility, and eliminate direct contact of contaminants by ecological receptors.	Advantages • Stabilization/Solidification is a proven technology for the treatment of PB- and SN-contaminated soil. • Surface and shallow subsurface soils are easily removed with conventional excavation equipment. • Vendors are readily available.	Advantages • No post-remediation monitoring and maintenance costs.
Disadvantages • Volume of contaminated soil increases by 20-30%. • Would not reduce the toxicity or volume of the contaminants. • Excavation would increase the dermal contact risk for on-site workers.	Disadvantages • Land disposal requirements may be invoked. • Treatability studies would be required to determine the optimal mixture of reagents. • Confirmatory sampling would be required to confirm treated soil meets treatment standards.	Disadvantages • Costs are for approximately 490,000 yd^3. • High costs for disposal in a RCRA-permitted landfill. • High cost for transportation. • Long-term liability associated with landfilled wastes.

CONCLUSION: There is no cost advantage for this technology over in situ treatment and it is therefore **eliminated** from further consideration.

Notes:

RCRA = Resource Conservation and Recovery Act
PB = Lead
SN = Tin

Table 6-14
Summary of Remedial Alternatives Screening
Settling Ponds and Spoils Disposal Area Soil

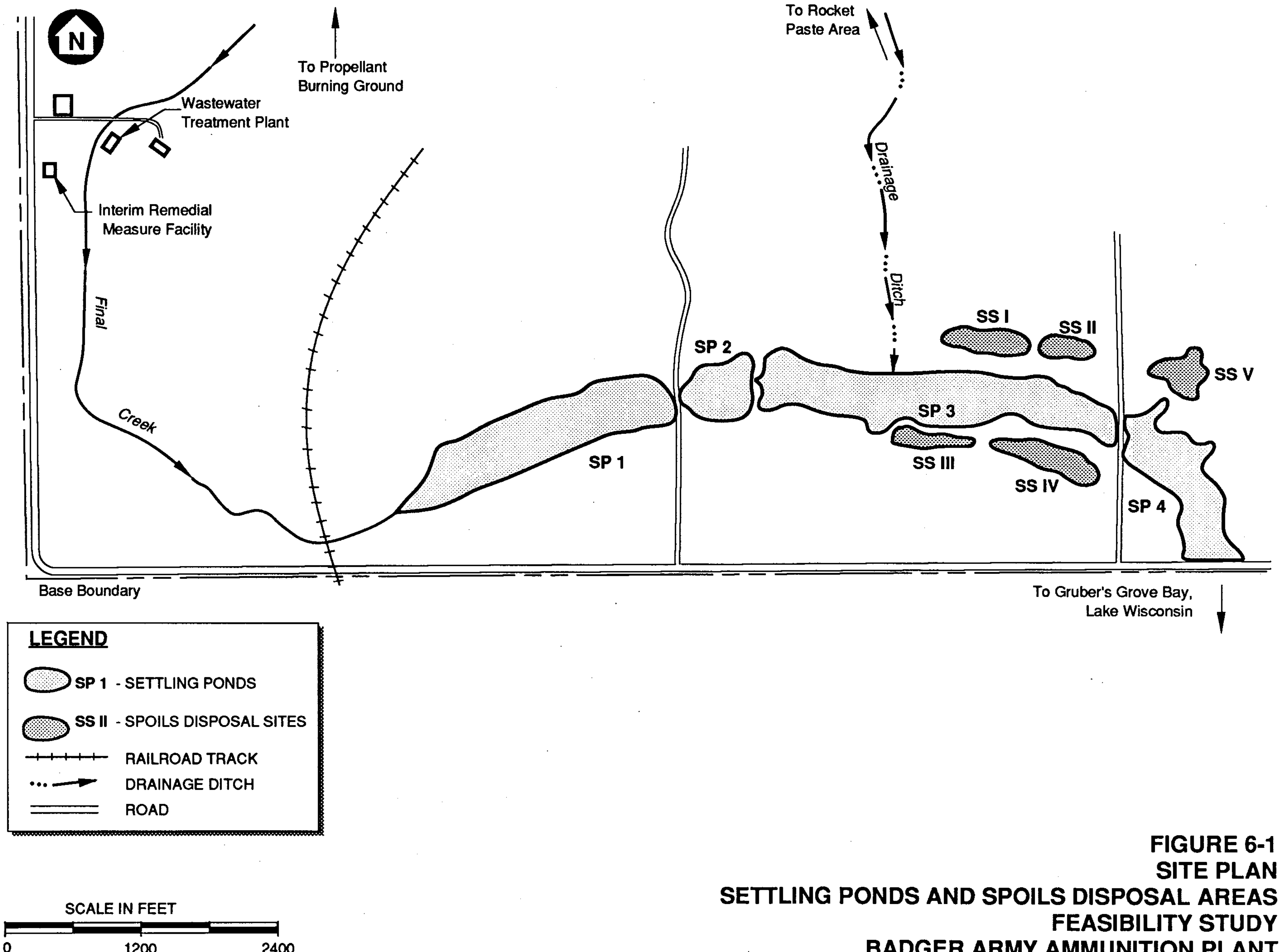
Feasibility Study
Badger Army Ammunition Plant

Alternative		Status
Alternative SSP-SS1:	Minimal Action	Retained for detailed analysis.
Alternative SSP-SS2:	Soil Cover	Eliminated from detailed analysis.
Alternative SSP-SS3:	Capping	Retained for detailed analysis.
Alternative SSP-SS4:	Off-site Landfill	Eliminated from detailed analysis.
Alternative SSP-SS5:	Soil Washing	Eliminated from detailed analysis.
Alternative SSP-SS6:	Ex-Situ Stabilization/ Solidification, Soil Cover	Eliminated from detailed analysis.
Alternative SSP-SS7:	In Situ Stabilization/ Solidification, Soil Cover	Retained for detailed analysis.
Alternative SSP-SS8:	Ex-Situ Stabilization/ Solidification, Off-site Landfill	Eliminated from detailed analysis.

TABLE 6-15
SUMMARY OF CONTAMINATION ASSESSMENT
THROUGH REMEDIAL ALTERNATIVES SCREENING
SETTLING PONDS AND SPOILS DISPOSAL AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

RI/FS COMPONENT	CONTAMINATED SOIL AT THE SETTLING PONDS AND SPOILS DISPOSAL AREA
	SURFACE SOILS
Identification of Contaminants of Concern	• SVOCs • Inorganics
Risk Assessment Results	• 24DNT, 26DNT, CPAH, PB, and ZN exceed human health and/or protection of groundwater criteria (as developed from proposed Chapter NR 720). • AL, DPA, DEP, NG, PB, SN, and ZN exceed acceptable ecological risk standards.
Remedial Action Objectives	• Prevent migration of contaminated soil by soil erosion. • Prevent the exposure of terrestrial receptors to surface soil at Final Creek and the Settling Ponds containing concentrations of PB (excluding Settling Pond 3) and SN that pose unacceptable risk. • Prevent the exposure to terrestrial receptors to surface soil containing concentrations of DEP (at Settling Ponds 1, 2, and 3) and DPA (at Final Creek and Settling Pond 1) that pose unacceptable risk. • Prevent the exposure of terrestrial receptors to surface soil at Settling Pond 4 containing concentrations of AL that pose unacceptable risk. • Prevent the exposure of terrestrial receptors to surface soil at the Spoils Disposal Sites containing concentrations of ZN and PB that pose unacceptable risk. • Prevent the exposure of terrestrial receptors to surface soil at Spoils Disposal Site 1 containing concentrations of DPA and NG that pose unacceptable risk. • Prevent the exposure of human receptors to soil at Final Creek and the Settling Ponds containing concentrations of 24DNT, 26DNT, and CPAH that pose unacceptable risk. • Prevent the exposure of human receptors to soil at the Spoils Disposal Sites containing concentrations of 24DNT that pose unacceptable risks. • Prevent concentrations of 24DNT and PB in soil at Final Creek and the Settling Ponds which exceed cleanup standards for protection of groundwater (developed from the proposed Chapter NR 720) from degrading groundwater quality in excess of WPALs. • Prevent concentrations of 24DNT, PB, and ZN in soil at the Spoils Disposal sites which exceed cleanup standards for protection of groundwater (developed from the proposed Chapter NR 720) from degrading groundwater quality in excess of WPALs.
Remedial Technologies Retained After Screening	• Soil Cover • Capping • Off-Site Landfill • Ex-Situ Stabilization/Solidification • In-Situ Stabilization/Solidification • Soil Washing



Source: Modified from Tsai, et.al., 1988.

FIGURE 6-1
SITE PLAN
SETTLING PONDS AND SPOILS DISPOSAL AREAS
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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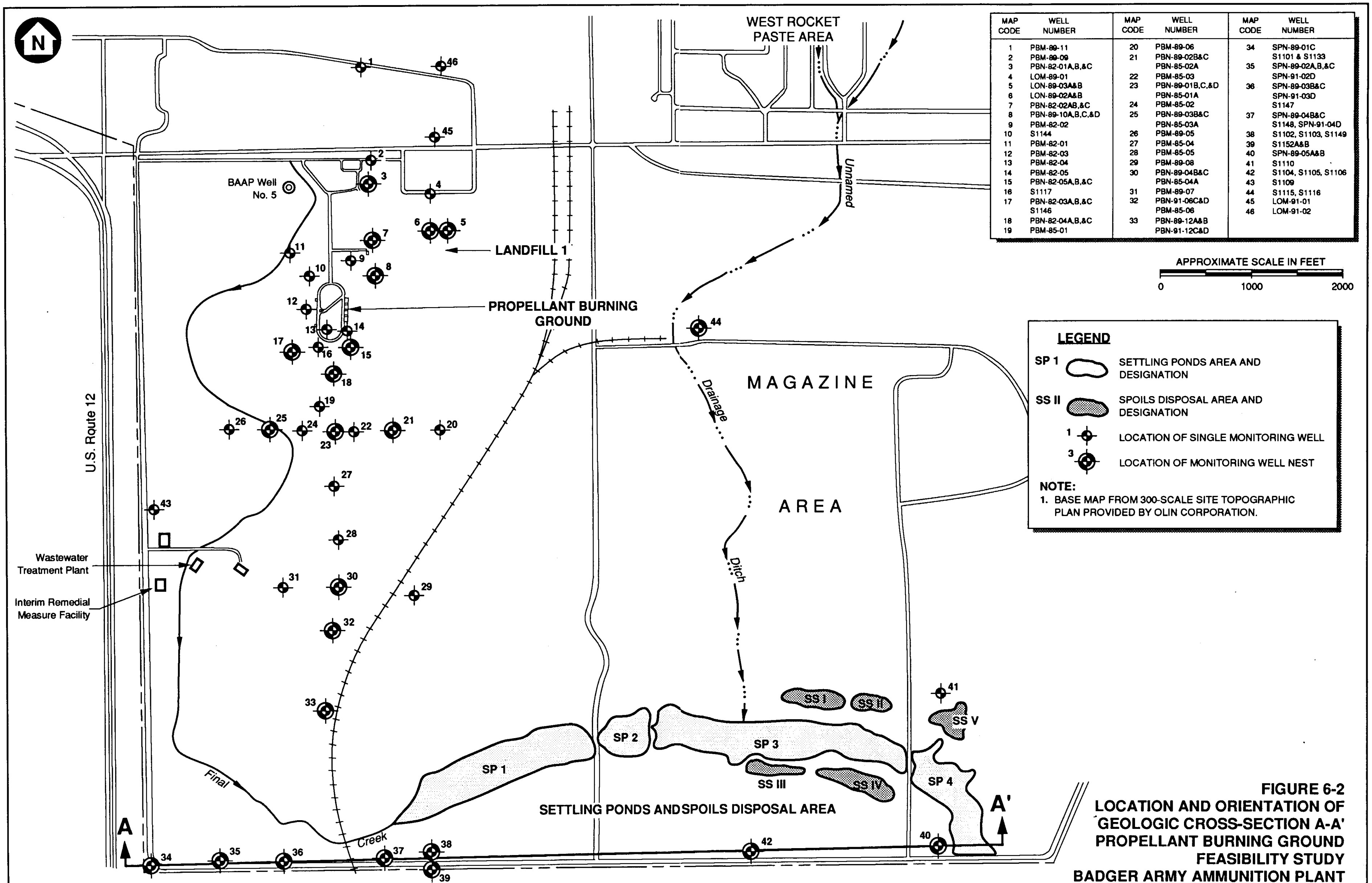

MAP CODE	WELL NUMBER	MAP CODE	WELL NUMBER	MAP CODE	WELL NUMBER
1	PBM-89-11	20	PBM-89-06	34	SPN-89-01C
2	PBM-89-09	21	PBN-89-02B&C		S1101 & S1133
3	PBN-82-01A,B,&C		PBN-85-02A	35	SPN-89-02A,B,&C
4	LOM-89-01	22	PBM-85-03		SPN-91-02D
5	LON-89-03A&B	23	PBN-89-01B,C,&D	36	SPN-89-03B&C
6	LON-89-02A&B		PBN-85-01A		SPN-91-03D
7	PBN-82-02AB,&C	24	PBM-85-02		S1147
8	PBN-89-10A,B,C,&D	25	PBN-89-03B&C	37	SPN-89-04B&C
9	PBM-82-02		PBN-85-03A		S1148, SPN-91-04D
10	S1144	26	PBM-89-05	38	S1102, S1103, S1149
11	PBM-82-01	27	PBM-85-04	39	S1152A&B
12	PBM-82-03	28	PBM-85-05	40	SPN-89-05A&B
13	PBM-82-04	29	PBM-89-08	41	S1110
14	PBM-82-05	30	PBN-89-04B&C	42	S1104, S1105, S1106
15	PBN-82-05A,B,&C		PBN-85-04A	43	S1109
16	S1117	31	PBM-89-07	44	S1115, S1116
17	PBN-82-03A,B,&C	32	PBN-91-06C&D	45	LOM-91-01
	S1146		PBM-85-06	46	LOM-91-02
18	PBN-82-04A,B,&C	33	PBN-89-12A&B		
19	PBM-85-01		PBN-91-12C&D		

FIGURE 6-2
LOCATION AND ORIENTATION OF GEOLOGIC CROSS-SECTION A-A'
PROPELLANT BURNING GROUND FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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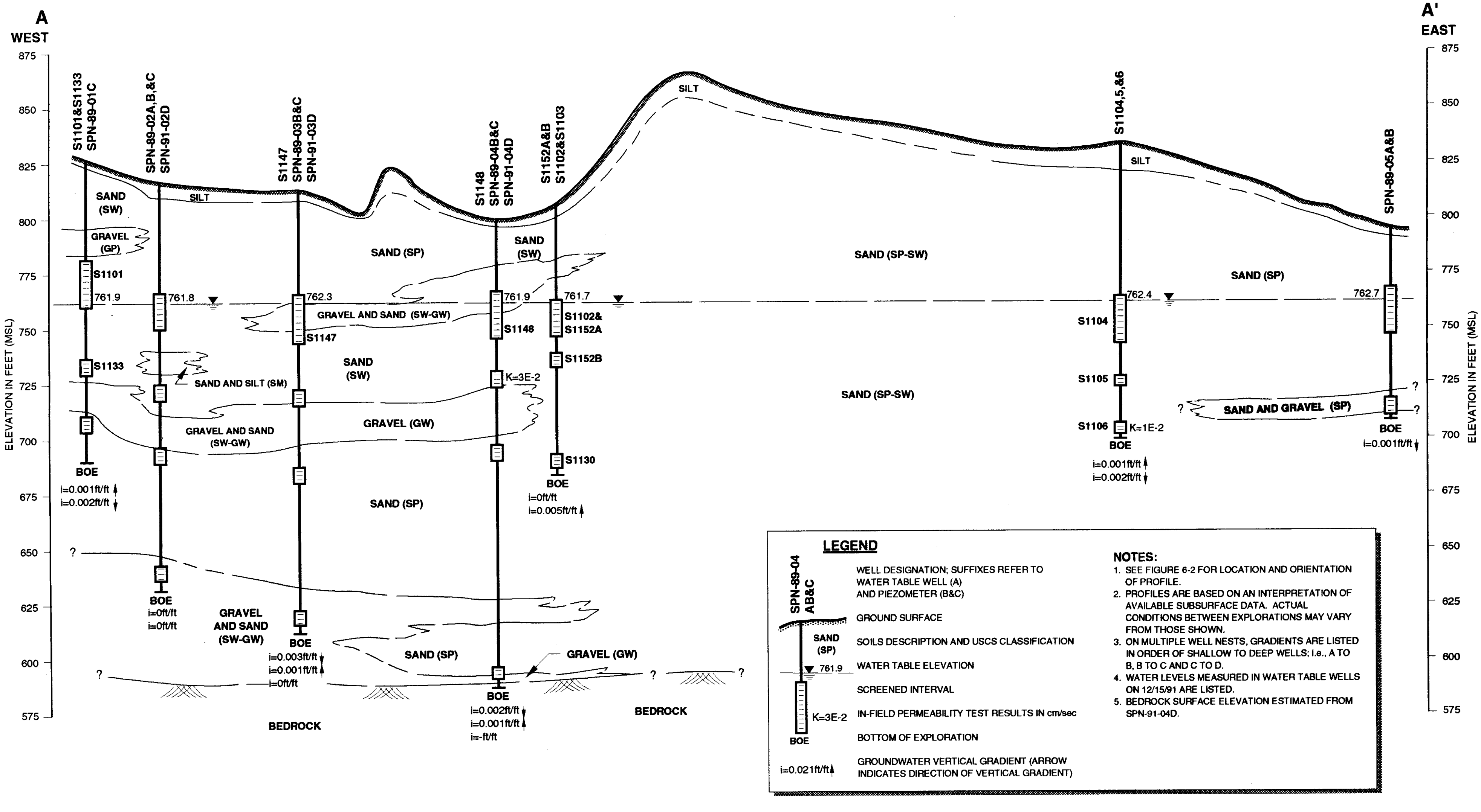

SCALE IN FEET
0 600 1200
VERTICAL EXAGGERATON 1:5

FIGURE 6-3
GEOLOGIC CROSS SECTION A-A'
SETTLING PONDS AND SPOILS DISPOSAL AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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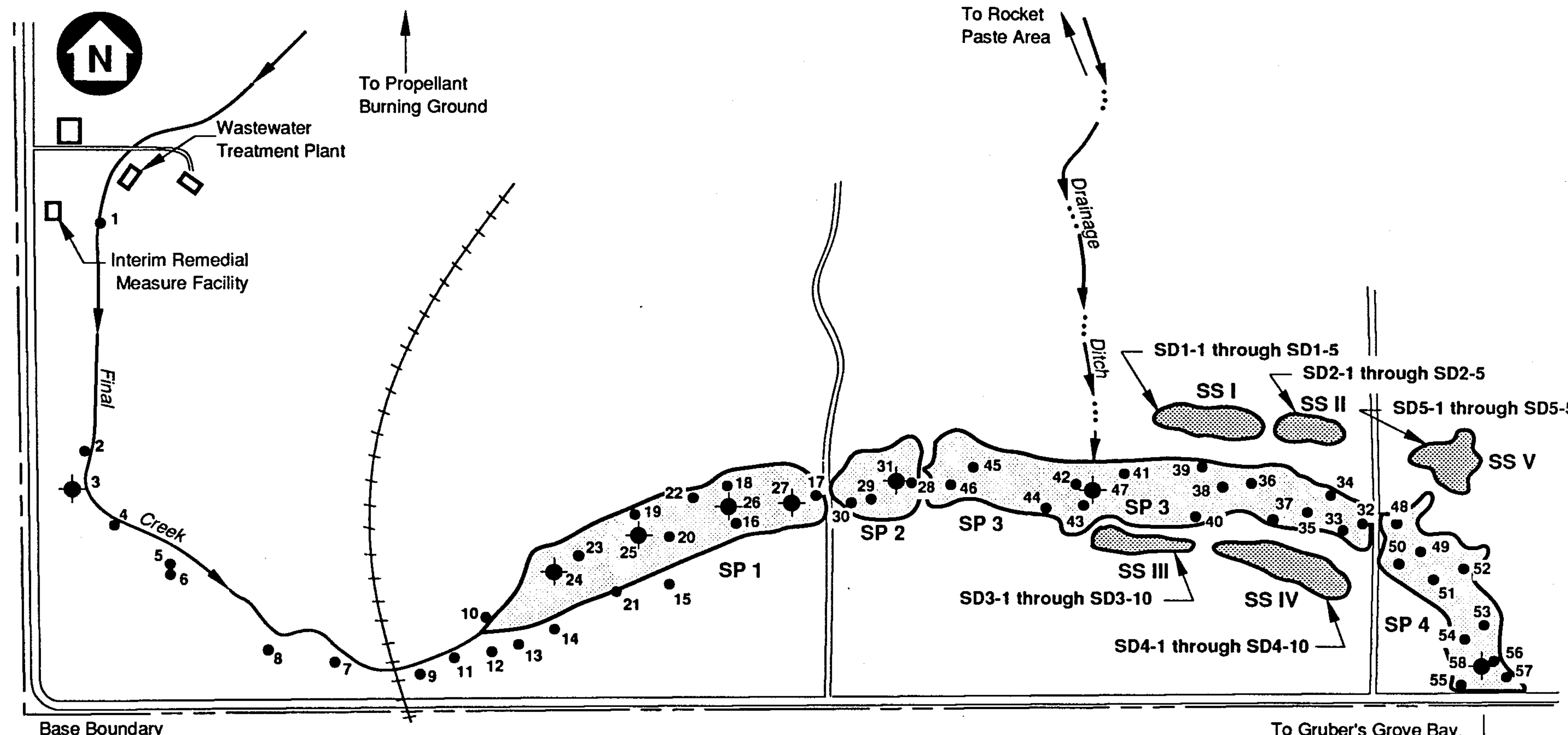

LEGEND

SP 1 - SETTLING PONDS

SS II - SPOILS DISPOSAL SITES

RAILROAD TRACK

DRAINAGE DITCH

ROAD

SOIL BORING LOCATION

SURFACE SOIL OR SEDIMENT SAMPLE LOCATION

SCALE IN FEET

0 1000 2000

Source: Modified from Tsai, et.al., 1988.

Map Code	Well No.	Map Code	Well No.	Map Code	Well No.	Map Code	Well No.	Map Code	Well No.
1	FC-1	13	FPI-1	25	S1202	37	FPIII-6	48	FPIV-1
2	FC-2	14	FPI-2	26	S1203	38	FPIII-7	49	FPIV-2
3	SPB-91-01	15	FPI-3	27	S1204	39	FPIII-8	50	FPIV-3
4	FC-3	16	FPI-4	28	FPII-1	40	FPIII-9	51	FPIV-4
5	FC-4	17	FPI-5	29	FPII-2	41	FPIII-10	52	FPIV-5
6	FC-5	18	FPI-6	30	FPII-3	42	FPIII-11	53	FPIV-6
7	FC-6	19	FPI-7	31	S1205	43	FPIII-12	54	FPIV-7
8	FC-7	20	FPI-8	32	FPIII-1	44	FPIII-13	55	FPIV-8
9	FC-8	21	FPI-12	33	FPIII-2	45	FPIII-14	56	FPIV-9
10	FPI-9	22	FPI-13	34	FPIII-3	46	FPIII-15	57	FPIV-10
11	FPI-10	23	FPI-14	35	FPIII-4	47	S1206	58	S1207
12	FPI-11	24	S1201	36	FPIII-5				

NOTE:
SURFACE SOIL AND SOIL BORING LOCATIONS ARE APPROXIMATED (AYERS, 1984, ENVIRONDYNE, 1981).

FIGURE 6-4
SURFACE AND SUBSURFACE EXPLORATION LOCATIONS SETTLING PONDS AND SPOILS DISPOSAL AREAS FEASIBILITY STUDY BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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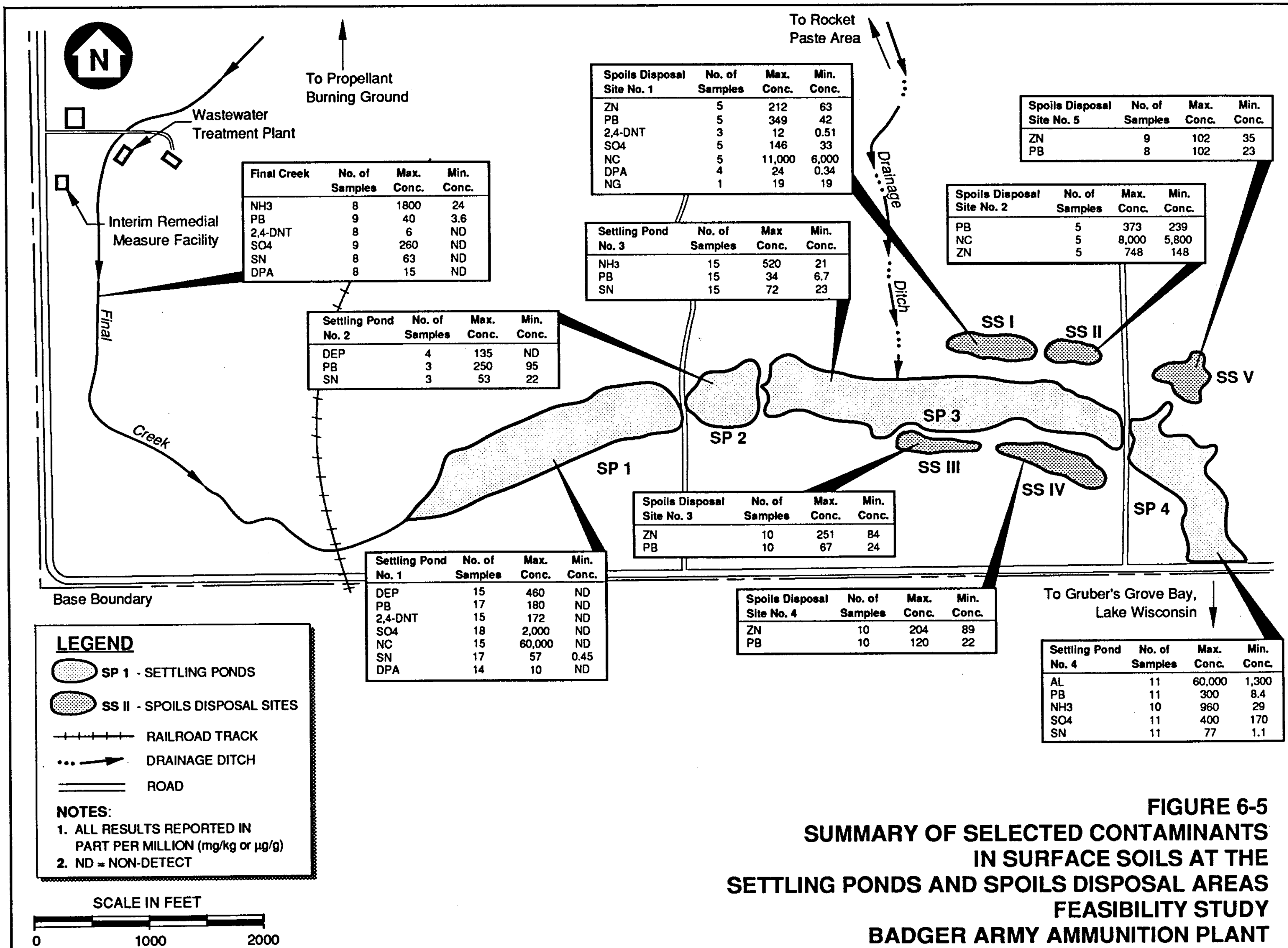

Final Creek	No. of Samples	Max. Conc.	Min. Conc.
NH3	8	1800	24
PB	9	40	3.6
2,4-DNT	8	6	ND
SO4	9	260	ND
SN	8	63	ND
DPA	8	15	ND

Settling Pond No. 2	No. of Samples	Max. Conc.	Min. Conc.
DEP	4	135	ND
PB	3	250	95
SN	3	53	22

Settling Pond No. 1	No. of Samples	Max. Conc.	Min. Conc.
DEP	15	460	ND
PB	17	180	ND
2,4-DNT	15	172	ND
SO4	18	2,000	ND
NC	15	60,000	ND
SN	17	57	0.45
DPA	14	10	ND

Spoils Disposal Site No. 1	No. of Samples	Max. Conc.	Min. Conc.
ZN	5	212	63
PB	5	349	42
2,4-DNT	3	12	0.51
SO4	5	146	33
NC	5	11,000	6,000
DPA	4	24	0.34
NG	1	19	19

Settling Pond No. 3	No. of Samples	Max Conc.	Min. Conc.
NH3	15	520	21
PB	15	34	6.7
SN	15	72	23

Spoils Disposal Site No. 3	No. of Samples	Max. Conc.	Min. Conc.
ZN	10	251	84
PB	10	67	24

Spoils Disposal Site No. 5	No. of Samples	Max. Conc.	Min. Conc.
ZN	9	102	35
PB	8	102	23

Spoils Disposal Site No. 2	No. of Samples	Max. Conc.	Min. Conc.
PB	5	373	239
NC	5	8,000	5,800
ZN	5	748	148

Spoils Disposal Site No. 4	No. of Samples	Max. Conc.	Min. Conc.
ZN	10	204	89
PB	10	120	22

Settling Pond No. 4	No. of Samples	Max. Conc.	Min. Conc.
AL	11	60,000	1,300
PB	11	300	8.4
NH3	10	960	29
SO4	11	400	170
SN	11	77	1.1

Source: Modified from Tsai, et.al., 1988.

FIGURE 6-5
SUMMARY OF SELECTED CONTAMINANTS IN SURFACE SOILS AT THE SETTLING PONDS AND SPOILS DISPOSAL AREAS FEASIBILITY STUDY BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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TABLE 7-1
GROUNDWATER SUMMARY
SOUTHERN OFF-POST AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUNDS OF POTENTIAL CONCERN	FREQUENCY OF DETECTION	MAXIMUM DETECTED CONCENTRATION (μg/L)	MINIMUM DETECTED CONCENTRATION (μg/L)	SDWA (1)		WI GROUNDWATER STANDARDS (2)		CALCULATED CONCENTRATION (3)
				MCL (μg/L)	MCLG (μg/L)	ES (μg/L)	PAL (μg/L)	
BA	2:2	24.8	24.3	2,000	2,000	2,000	400	-
CCL4	8:52	10.8	1.68	5	0	5	0.5	-
CD	1:42	2.78	-	5	5	5	0.5	-
CHCL3	6:52	1.31	0.433	-	-	6	0.6	-
CL	42:42	49,000	3,100	250,000(a)	-	-	-	-
CR	16:42	14.5	4.61	100	100	100	10	-
MN	2:2	54.1	29.7	50(a)	-	50(c)	25(c)	-
NA	2:2	27,000	25,000	20,000(b)	-	-	-	-
NIT	42:42	27,000	1,300	10,000	10,000	10,000	2,000	-
PB	1:42	5.6	-	TT	0	15	1.5	-
SO4	42:42	64,000	18,000	250,000(a)	-	250,000(c)	125,000(c)	-
TRCLE	2:52	0.425	0.287	5	0	5	0.5	-

Sources:

(1) U.S. Environmental Protection Agency (USEPA), 1991, "Fact Sheet: National Primary Drinking Water Standards." Office of Water, Washington, D.C., August 1991; USEPA, 1991, "Fact Sheet: National Secondary Drinking Water Standards," Office of Water, Washington, D.C., September 1991; and USEPA, 1990, "National Primary and Secondary Drinking Water Regulations; Synthetic Organic Chemicals and Inorganic Chemicals, Final Rule," 57FR31776, July 17, 1992.
(2) Wisconsin Administrative Code, Chapter NR 140.10, Table 1.
(3) Calculated to be protective at risk of 10^{-6} or HI of 1.

Notes:

(a) Secondary drinking water standard, suggested level.
(b) Reporting level. Monitoring is required and data is reported to health officials to protect individuals on restricted sodium diet.
(c) Values for protection of public welfare (usually aesthetic concerns) rather than for protection of public health.

μg/L = micrograms per liter
SDWA = Safe Drinking Water Act
MCL = Maximum Contaminant Level
MCLG = Maximum Contaminant Level Goal
WI = Wisconsin
ES = Enforcement Standard
PAL = Preventive Action Limit
TT = Treatment technique requirement in effect
Copper action level = 1,300 μg/L
Lead action level = 15 μg/L

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

TABLE 7-2
GENERAL RESPONSE ACTIONS AND POTENTIAL REMEDIAL TECHNOLOGIES
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GENERAL RESPONSE ACTION	GROUNDWATER TECHNOLOGY	DESCRIPTION
No Action	Groundwater Monitoring	Perform water quality analyses to monitor contaminant migration and assess future environmental impacts.
Minimal Action	Institutional Controls/ Education Programs	Restrictions on use of contaminated groundwater. Educate public concerning site hazards.
Containment	Slurry Wall	Emplacement of a low-permeability barrier to restrict groundwater migration. Should include a cover system to reduce infiltration.
Collection	Groundwater Extraction Wells	Installation of several strategically located pumping wells to collect contaminated groundwater for treatment.
Treatment	UV/Oxidation	Oxidize VOCs in extracted groundwater through simultaneous application of UV light and ozone or hydrogen peroxide.
	UV/Reduction	Chemically reduce VOCs in extracted groundwater through simultaneous application of UV light and a proprietary liquid catalyst.
	Air Stripping	Reduce concentrations of VOCs through intimate contact of extracted groundwater with air. Water descends a packed column while air is forced up the column to promote mass transfer of organics from aqueous to gaseous phase.
	Carbon Adsorption	Reduce concentrations of aqueous or gaseous phase VOCs through adsorption onto granular activated carbon. May be used as a polishing step for treatments such as air stripping to further reduce VOC concentrations in groundwater or to capture VOCs in air stripper emissions. Process produces a concentrated waste stream requiring further treatment.

continued

TABLE 7-2
GENERAL RESPONSE ACTIONS AND POTENTIAL REMEDIAL TECHNOLOGIES
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GENERAL RESPONSE ACTION	GROUNDWATER TECHNOLOGY	DESCRIPTION
	Resin Adsorption	Contaminants are transferred from the dissolved state to the surface of the resin. Resin can be regenerated by removing the contaminants with steam or solvent. Process produces a concentrated waste stream requiring further treatment.
In Situ Treatment	In Situ Biological	Introduce nutrients and oxygen or methane into the groundwater using a matrix of extraction wells and recirculation techniques.
Discharge	Off-Site Water Treatment Facility	Off-site disposal of extracted groundwater to a POTW. Groundwater would require transport by means of a force main and/or gravity feed sewer or by truck to the POTW.
	Groundwater Reinjection	Reinject treated groundwater using a series of wells and pumps. Can be used to enhance plume removal and accelerate remediation.
	Discharge to Surface Water	Discharge treated groundwater directly to nearby surface water body. Transport groundwater by means of force or gravity main.

Notes:

POTW = Publicly Owned Treatment Works
UV = ultraviolet
VOCs = volatile organic compounds

TABLE 7-3
REMEDIAL TECHNOLOGY SCREENING
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
Groundwater Monitoring	· Monitors short- and long-term effectiveness of remedial technologies when used during and after remediation.	· Would not reduce mobility, toxicity, or volume of contaminants when used alone.	Retained	Required component of groundwater remediation.
Institutional Controls/ Educational Programs	· Reduces exposure potential for human receptors. · Easily implemented.	· Would not reduce mobility, toxicity, or volume of contaminants. · May require future groundwater treatment.	Retained	Partially protective of human health and is easily implemented.
Slurry Wall	· May reduce mobility of contaminants present in groundwater. · Would reduce potential for off-site impact from contaminants present in groundwater.	· Current construction methods/equipment are limited to a depth of 200 feet below ground surface. · Containment would not reduce the toxicity or volume of contaminants in groundwater. · Contaminants may degrade slurry wall material.	Eliminated	Current construction methods/equipment incapable of constructing a slurry wall to a depth of 250 feet, as would be required at the Southern Off-Post Area.
Groundwater Extraction Wells	· Groundwater extraction systems have been successfully implemented in similar hydrogeologic conditions.	· Wells must be strategically located so that cones of depression intersect and capture all contaminated groundwater.	Retained	Groundwater extraction wells required for pump and treat alternatives.
UV/Reduction	· Treatment provides permanent on-site destruction of organics into carbon dioxide and water, or nontoxic intermediates. · No air emissions or sludge is produced during the treatment process. · Destruction of saturated chlorinated VOCs proven during pilot-scale operation.	· Reliability of this technology has not been demonstrated. · Treatability study should be performed prior to full-scale design to determine operating parameters and pretreatment requirements necessary to optimize operating efficiency.	Eliminated	Significant treatment costs associated with operation.

continued

TABLE 7-3
REMEDIAL TECHNOLOGY SCREENING
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
UV/Oxidation	· Treatment provides permanent on-site destruction of organics into carbon dioxide and water, or nontoxic intermediates. · No air emissions or sludge is produced during the treatment process. · Destruction of VOCs proven during full-scale operation.	· Difficulty in treating saturated chlorinated VOCs, such as CCL4. · Treatability study should be performed prior to full-scale design to determine operating parameters and pretreatment requirements necessary to optimize operating efficiency.	Eliminated	Not an energy-efficient technology for treatment of saturated VOCs (e.g. CCL4 and CHCL3)
Air Stripping	· Treatment would reduce the volume of contaminants in groundwater. · Air Stripping is a proven and reliable technology for treatment of VOCs.	· Off-gases produced during remediation may require collection/treatment/disposal. · Treatment is not effective for compounds with low volatility. · Pretreatment for the removal of inorganics required to prevent fouling of air-stripper system. · Post-treatment by carbon adsorption may be required to meet discharge limits.	Retained	Retained for treatment of VOCs in Southern Off-Post Area groundwater.
Carbon Adsorption	· Treatment effectively removes organic material from groundwater by sorption. · Technology is reliable and has been demonstrated for treating VOCs/SVOCs at full-scale. · Carbon adsorption could be implemented as a polishing step after air stripping to meet discharge requirements.	· Suspended solids may require removal prior to treatment to avoid clogging carbon bed. · Spent carbon from the adsorption process would require disposal or regeneration.	Retained	Retained for treatment of VOCs in Southern Off-Post Area groundwater.
Resin Adsorption	· Treatment would reduce the volume of chemicals in groundwater. · Removes VOCs/SVOCs and metals from the wastewater stream. · Capable of treating high flows.	· Process concentrates contaminants within the resin column, necessitating regeneration or disposal of the resin. · Reliability of this technology has not been demonstrated, particularly for groundwater treatment.	Eliminated	Potentially significant treatability study costs. Full scale systems have not been constructed.

continued

TABLE 7-3
REMEDIAL TECHNOLOGY SCREENING
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

REMEDIAL TECHNOLOGY	ADVANTAGES	DISADVANTAGES	SCREENING STATUS	COMMENTS
In situ Biological Treatment	· Treatment would reduce volume, toxicity, and mobility of chemicals present in groundwater. · Contaminants are degraded to non-toxic compounds. · No air emissions or secondary waste streams are produced. · Recirculation equipment is off-the-shelf.	· Significant time and expense for laboratory degradation studies and field demonstrations. · Chlorinated VOCs/SVOCs (e.g., CCL4) can be difficult to treat. · Parameters (e.g., temperature, pH, nutrients, and oxygen) for optimal microorganism growth can be difficult to maintain. · Injection wells are susceptible to plugging by chemical precipitation of nutrients.	Eliminated	Not a demonstrated technology for remediation of Southern Off-Post Area contaminants.
Off-Site Water Treatment Facility	· If sewer connection is nearby, this can be a relatively inexpensive discharge option.	· Approval by POTW, community, and WDNR may be difficult.	Eliminated	Discharge to surface water is the preferred option.
Groundwater Reinjection	· Groundwater not meeting remedial goals may be reinjected upgradient for further treatment via pump-and-treat technology.	· Infiltration of treated groundwater could affect the migration of contaminants. · Reinjection of water into the plume's path may alter the extraction system's ability to collect contaminated groundwater. · Mixing treated water with untreated groundwater in a reinjection well may cause metal precipitation.	Eliminated	Discharge to surface water is the preferred option.
Discharge to Surface Water	· Wisconsin River is in close proximity to the southern boundary of the Southern Off-Post Area.	· Discharge water must meet applicable discharge standards developed by WDNR.	Retained	IRM facility currently discharges to Lake Wisconsin, therefore, obtaining regulatory approval is not expected to be difficult.

Notes:

BAAP	=	Badger Army Ammunition Plant
IRM	=	Interim Remedial Measure
MW	=	megawatt
PBG	=	Propellant Burning Ground
POTW	=	Publicly owned treatment works
RCRA	=	Resource Conservation and Recovery Act
SVOCs	=	semivolatile organic compounds
TSCA	=	Toxic Substances Control Act
UV	=	ultraviolet
VOCs	=	volatile organic compounds
WDNR	=	Wisconsin Department of Natural Resources

Full compound names are identified in the USAEC Chemical Code List located behind the Glossary of Acronyms.

TABLE 7-4
REMEDIAL TECHNOLOGIES RETAINED FOR REMEDIAL ALTERNATIVES DEVELOPMENT
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

MINIMAL ACTION[1]	COLLECTION & TREATMENT[1]	IN-SITU TREATMENT[1]	DISCHARGE
Institutional Controls/ Education Programs	Groundwater Extraction Wells Air Stripping Carbon Adsorption	None	Surface Water

Notes:

[1]Groundwater monitoring would be used in conjunction with these technologies.
UV = Ultraviolet

TABLE 7-5
IDENTIFICATION OF REMEDIAL ALTERNATIVES
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVES	ACTION				
	MINIMAL ACTION	GROUNDWATER EXTRACTION WELLS	AIR STRIPPING	CARBON ADSORPTION	DISCHARGE TO SURFACE WATER
SOPA-GW1	X				
SOPA-GW2		X	X		X
SOPA-GW3		X		X	X

Note:

X = Identified technology is a component of alternative.

TABLE 7-6
DEVELOPMENT OF REMEDIAL ALTERNATIVES
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Remedial Action Objective:

(1) Prevent concentrations of CCL4, CHCL3, TRCLE, CD, MN, and PB in groundwater, which exceed WPALs, from becoming available to potential human receptors.

ALTERNATIVE	DESCRIPTION OF KEY COMPONENTS
SOPA-GW1: Minimal Action	• Institutional controls. Implement zoning and deed restrictions to prohibit use of groundwater within and around the site. • Education programs. • Groundwater monitoring. Perform water quality analyses to monitor contaminant migration and assess future environmental impacts. • Five-year site reviews.
SOPA-GW2: Air Stripping	• Install groundwater extraction system. • Construct air stripping treatment facility. • Extract groundwater and treat in the new facility. • Discharge treated water to the Wisconsin River. • Monitor effluent as required by WDNR permit requirements. • Groundwater monitoring. Perform water quality analyses to monitor cleanup progress. • Five-year site reviews.
SOPA-GW3: Carbon Adsorption	• Install groundwater extraction system. • Construct carbon adsorption treatment facility. • Extract groundwater and treat in the new facility. • Discharge treated water to the Wisconsin River. • Monitor effluent as required by WDNR permit requirements. • Groundwater monitoring. Perform water quality analyses to monitor cleanup progress. • Five-year site reviews.

Notes:

WDNR = Wisconsin Department of Natural Resources
WPAL = Wisconsin Preventative Action Limit

Full compound names are identified in the USAEC Chemical Code List located behind the Glossary of Acronyms.

TABLE 7-7
SCREENING OF REMEDIAL ALTERNATIVES
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative SOPA-GW1: Minimal Action: This alternative consists of institutional controls, educational programs, groundwater monitoring, and five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives. • Institutional controls would reduce the potential for future groundwater use. • Educational program would increase public awareness about contaminated groundwater. • Site water quality would be monitored to assess the affect of implementing Propellant Burning Ground groundwater remediation.	Advantages • Would be easy to implement because no remedial actions are required. • Services and material readily available. • Future groundwater remediation not necessary as long as Propellant Burning Ground remediation prevents further contaminant migration to off-post area.	Advantages • Minimal cost for administration of institutional controls and educational programs. • Allows funds to be directed toward the more effective source treatment at the Propellant Burning Ground.
Disadvantages • Would not reduce mobility, toxicity, or volume of chemicals in groundwater.	Disadvantages • Long-term monitoring and maintenance provisions would be required.	Disadvantages • Long-term costs associated with operation and maintenance of monitoring systems.

CONCLUSION: The minimal action alternative is **retained** because this alternative is able to comply with the remedial objectives at the Southern Off-Post Area.

continued

TABLE 7-7
SCREENING OF REMEDIAL ALTERNATIVES
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative SOPA-GW2: Air Stripping: This alternative consists of construction and operation of an air stripping treatment facility. This alternative includes groundwater extraction, treatment, effluent monitoring, discharge to the Wisconsin River, groundwater monitoring, and five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives. • Extraction system would capture the SOPA plume. • Reduces the mobility of groundwater contaminants. • Air stripping is efficient for treatment of principal groundwater contaminants.	Advantages • Successful performance of air stripper units is well documented. • Experienced vendors are available to provide equipment and services. • Systems can accommodate a range of flow rates.	Advantages • Capital and operation and maintenance costs are comparable to other water treatment processes.
Disadvantages • Treatment residuals must be transported and treated off-site.	Disadvantages • May require pretreatment for suspended solids, carbonate/ bicarbonates, and/or metals to prevent fouling of air stripper packing. • Treatment (e.g., vapor-phase carbon) may be required for air stripper emissions. • Spent carbon from the process requires off-site treatment.	Disadvantages • Significant short-term (i.e., during groundwater remediation) costs associated with monitoring program for groundwater quality and treatment facility discharge.

CONCLUSION: Because this alternative achieves remedial action objectives and includes efficient treatment of groundwater contaminants, it is **retained** for detailed analysis.

continued

TABLE 7-7
SCREENING OF REMEDIAL ALTERNATIVES
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Alternative SOPA-GW3: Carbon Adsorption: This alternative consists of construction and operation of a carbon adsorption treatment facility. This alternative includes groundwater extraction, treatment, effluent monitoring, discharge to the Wisconsin River, groundwater monitoring, and five-year site reviews.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages • Achieves remedial action objectives. • Extraction system would capture the SOPA plume. • Reduces the mobility of groundwater contaminants. • Off-site thermal reactivation of spent carbon destroys contaminants.	Advantages • Successful performance of carbon adsorption is well documented. • Treatability studies not required. • Carbon adsorption system components are easy to install and relatively simple to operate.	Advantages • Potentially low capital cost.
Disadvantages • Produces a large volume of treatment residuals which must be transported and treated off site.	Disadvantages • Spent carbon from the process requires off-site treatment.	Disadvantages • Significant short-term (i.e., during groundwater remediation) costs associated with monitoring program for groundwater quality and treatment facility discharge. • Potentially high operating cost associated with purchase of new carbon for every change-out.

CONCLUSION: Because carbon adsorption achieves remedial action objectives and is a demonstrated technology, this alternative is **retained** for detailed analysis.

Notes:

SOPA = Southern Off-Post Area
VOC = volatile organic compound

TABLE 7-8
SUMMARY OF REMEDIAL ALTERNATIVES SCREENING
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE		STATUS
Alternative SOPA-GW1:	Minimal Action	Retained for detailed analysis.
Alternative SOPA-GW2:	Air Stripping	Retained for detailed analysis.
Alternative SOPA-GW3:	Carbon Adsorption	Retained for detailed analysis.

Note:

SOPA = Southern Off-Post Area

TABLE 7-9
SUMMARY OF CONTAMINATION ASSESSMENT THROUGH REMEDIAL ALTERNATIVES SCREENING SOUTHERN OFF-POST AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

RI/FS Component	Contaminated Media at the Southern Off-Post Area Groundwater
Identification of Contaminants of Concern	• VOCs • Inorganics
Risk Assessment Results	• CCL4 exceeds MCL, WES, and WPAL • CHCL3, CD, PB, and TRCLE exceed WPALs but are below MCL and WES • MN exceeds secondary drinking water standards, and public welfare standards
Remedial Action Objective	• Prevent concentrations of CCL4, CHCL3, TRCLE, CD, MN, and PB in groundwater which exceed WPALs from becoming available to potential human receptors
Remedial Technologies Retained After Screening	• Groundwater monitoring • Institutional controls • Groundwater extraction wells • Airstripping • Carbon adsorption • Surface Water Discharge
Remedial Alternatives Developed	• Minimal Action • Airstripping • Carbon adsorption
Remedial Alternatives Retained After Screening	• Minimal Action • Airstripping • Carbon adsorption

Notes:

WES = Wisconsin Enforcement Standard
WPAL = Wisconsin Preventative Action Limit

Full compound names are identified in the USAEC Chemical Code list located behind the glossary of acronyms.

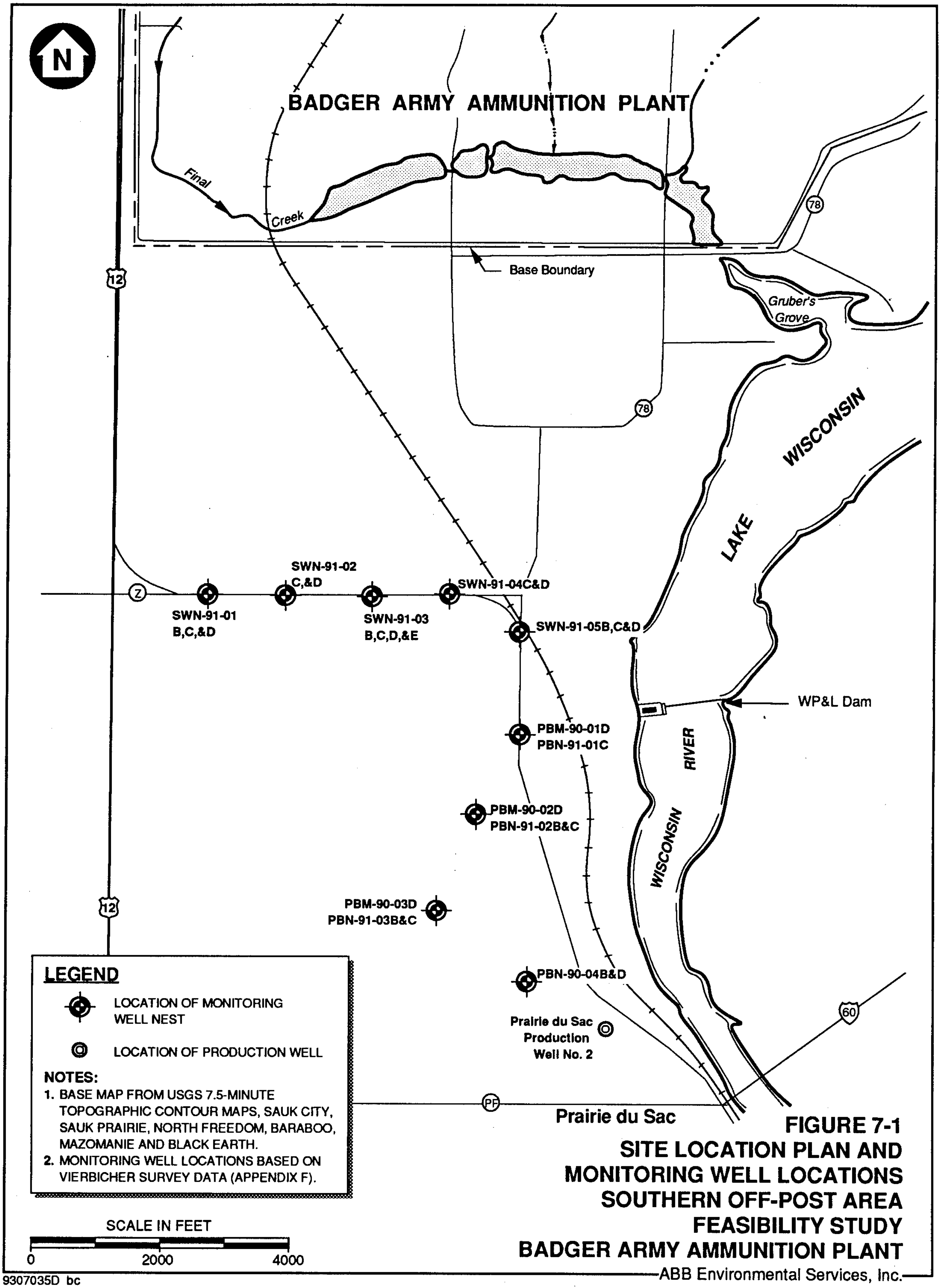


FIGURE 7-1
SITE LOCATION PLAN AND MONITORING WELL LOCATIONS
SOUTHERN OFF-POST AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9307035D bc

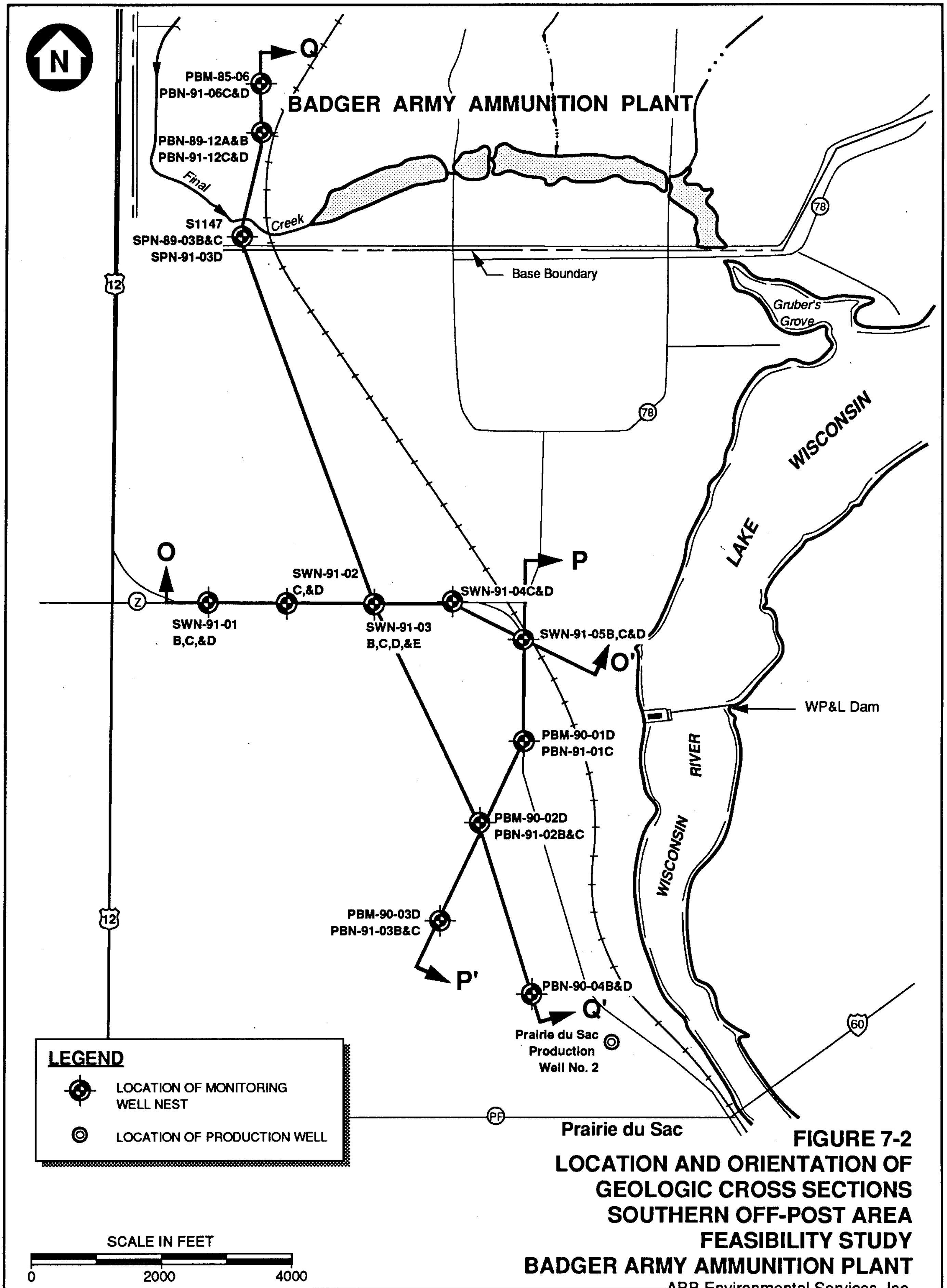
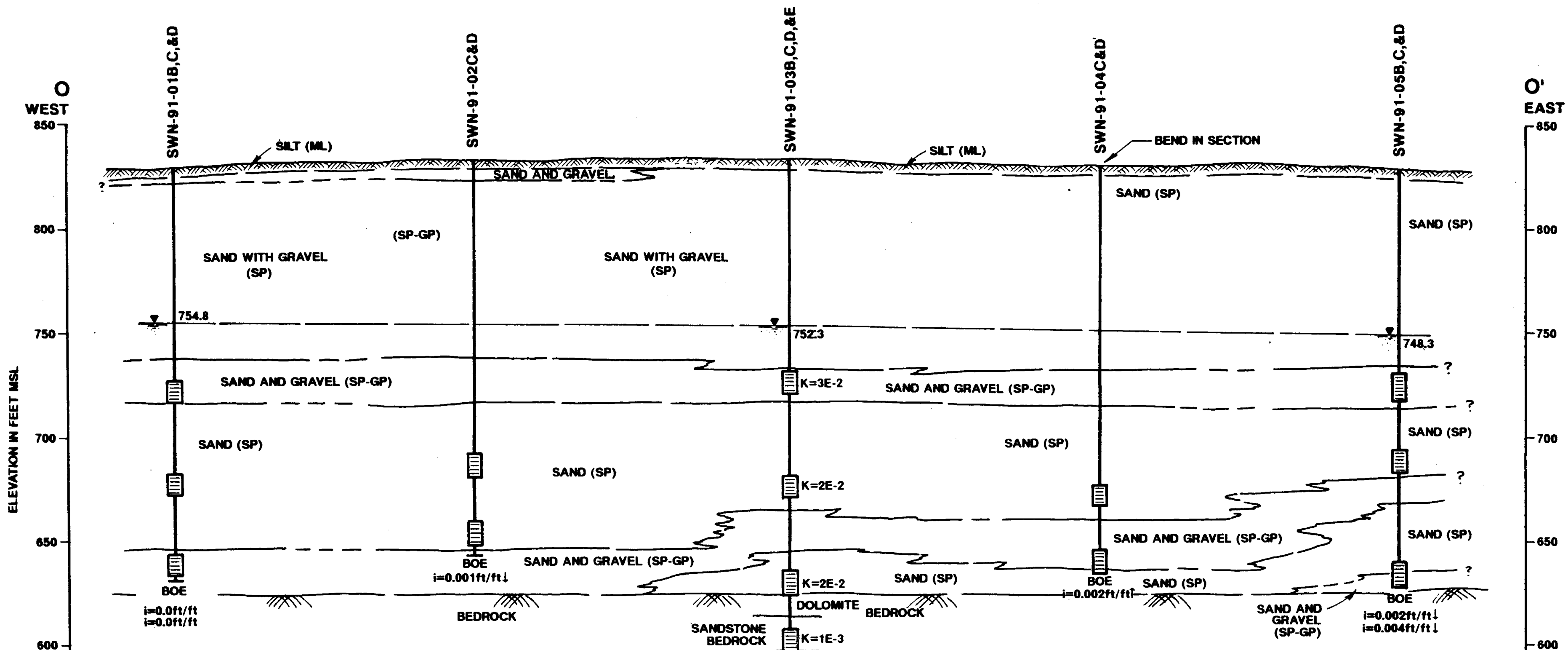


FIGURE 7-2
LOCATION AND ORIENTATION OF GEOLOGIC CROSS SECTIONS SOUTHERN OFF-POST AREA FEASIBILITY STUDY BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9307035D b fg



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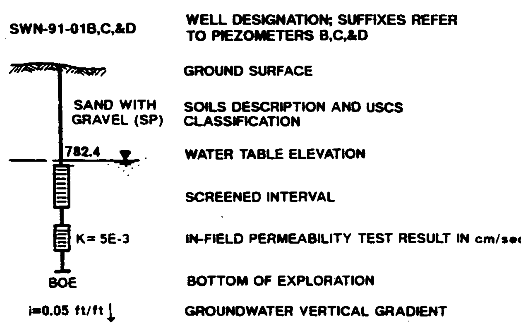


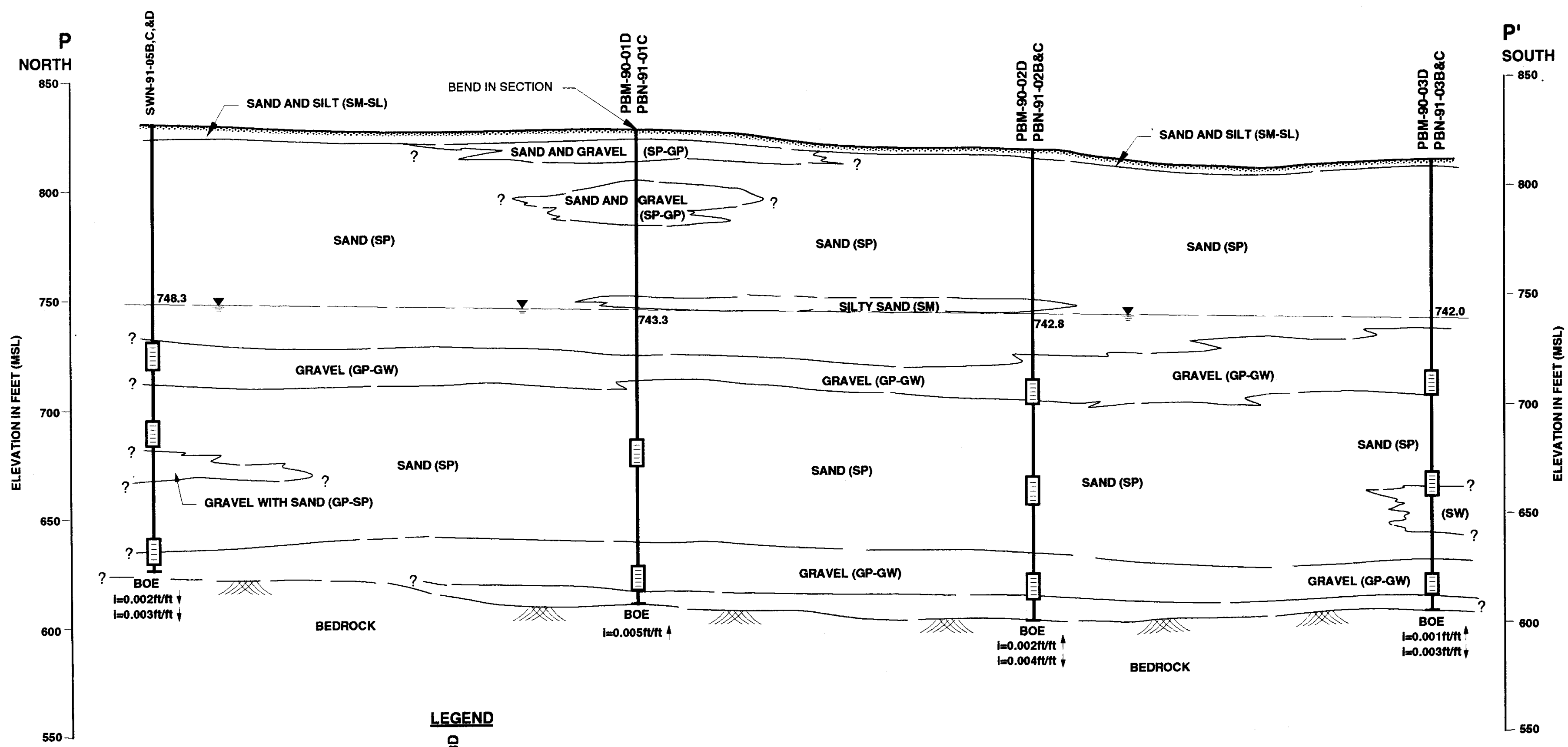
NOTES:

1. SEE FIGURE 7-2 FOR LOCATION AND ORIENTATION OF PROFILES.
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA. ACTUAL CONDITIONS BETWEEN EXPLORATIONS MAY VARY FROM THOSE SHOWN.
3. ON MULTIPLE WELL NESTS, GRADIENTS ARE LISTED IN ORDER OF SHALLOW TO DEEP WELLS; B TO C, C TO D, AND D TO E.
4. WATER LEVELS MEASURED IN B-SERIES PIEZOMETERS ON 12/15/91 ARE LISTED.
5. BEDROCK SURFACE ELEVATION ESTIMATED FROM SWN-91-03D&E.

FIGURE 7-3
GEOLOGIC CROSS SECTION O-O'
SOUTHERN OFF-POST AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

6853-12/9202151T



NOTES:
1. SEE FIGURE 7-2 FOR LOCATION AND ORIENTATION OF PROFILES.
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA. ACTUAL CONDITIONS BETWEEN EXPLORATIONS MAY VARY FROM THOSE SHOWN.
3. WATER LEVELS MEASURED IN WATER TABLE WELLS ON 12/15/91.

SCALE IN FEET
0 400 800
VERTICAL EXAGGERATON 1:8

LEGEND

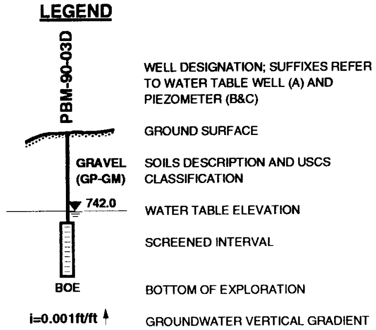


FIGURE 7-4
GEOLOGIC CROSS SECTION P-P'
SOUTHERN OFF-POST AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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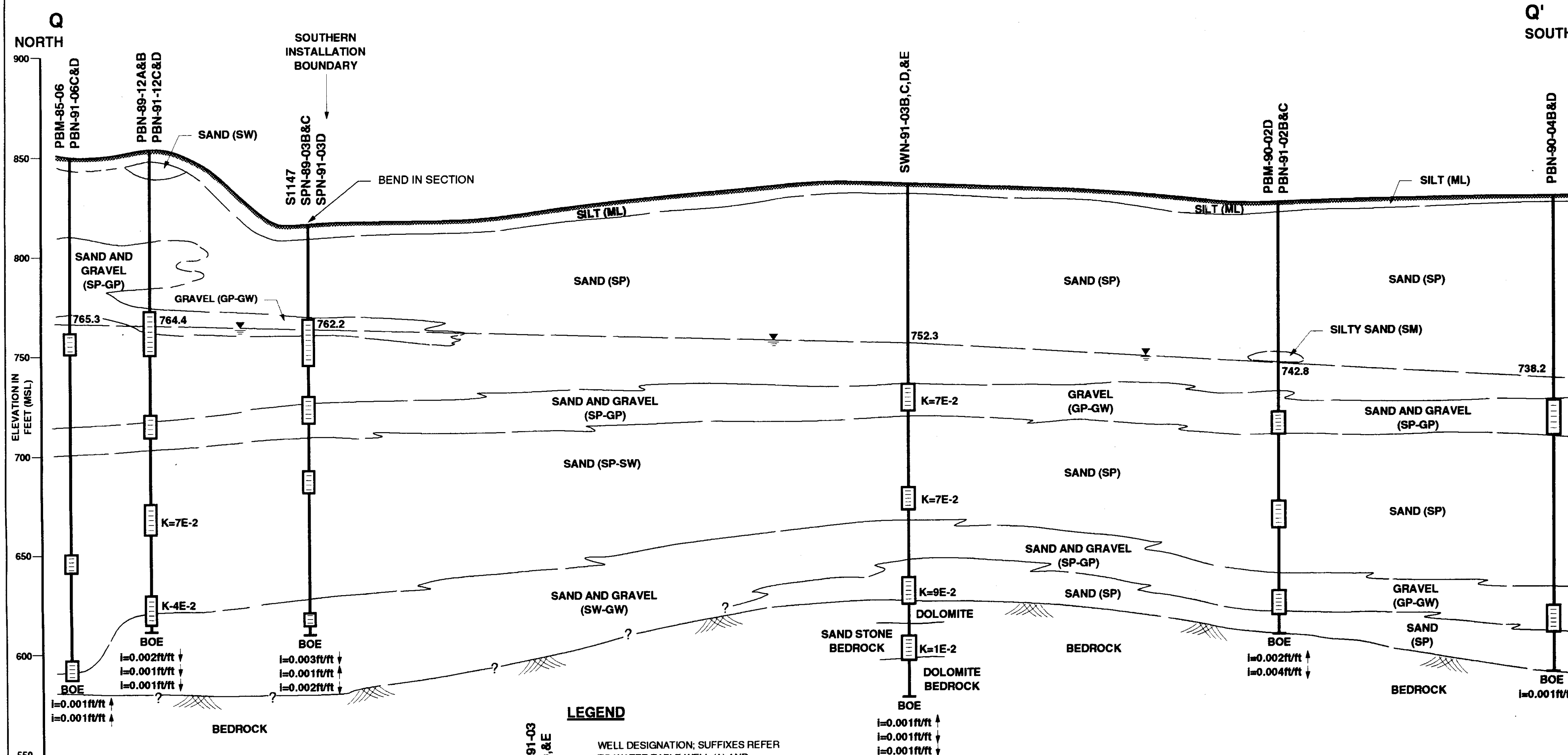

NOTES:
1. SEE FIGURE 7-2 FOR LOCATION AND ORIENTATION OF PROFILES.
2. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA. ACTUAL CONDITIONS BETWEEN EXPLORATIONS MAY VARY FROM THOSE SHOWN.
3. WATER LEVELS MEASURED IN WATER TABLE WELLS ON 12/15/91.

SCALE IN FEET

0 1000 2000

VERTICAL EXAGGERATON 1:20

LEGEND

SWN-91-03 B,C,D,&E	WELL DESIGNATION; SUFFIXES REFER TO WATER TABLE WELL (A) AND PIEZOMETER (B&C)
	GROUND SURFACE
SAND (SP)	SOILS DESCRIPTION AND USCS CLASSIFICATION
752.3	WATER TABLE ELEVATION
	SCREENED INTERVAL
K=7E-2	IN-FIELD PERMEABILITY TEST RESULT IN cm/sec
BOE	BOTTOM OF EXPLORATION
i=0.001ft/ft	GROUNDWATER VERTICAL GRADIENT

FIGURE 7-5
GEOLOGIC CROSS SECTION Q-Q'
SOUTHERN OFF-POST AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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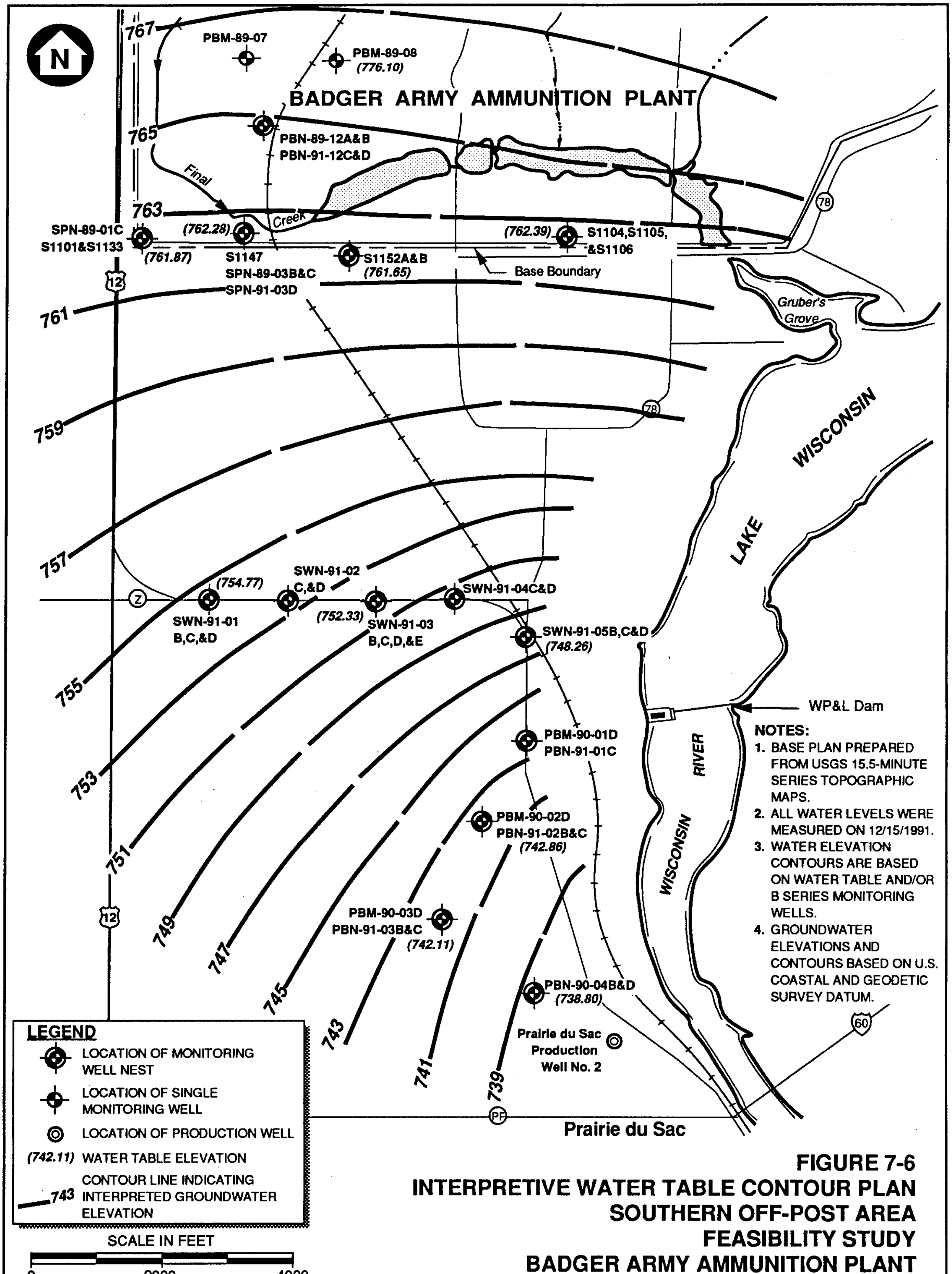

FIGURE 7-6
INTERPRETIVE WATER TABLE CONTOUR PLAN
SOUTHERN OFF-POST AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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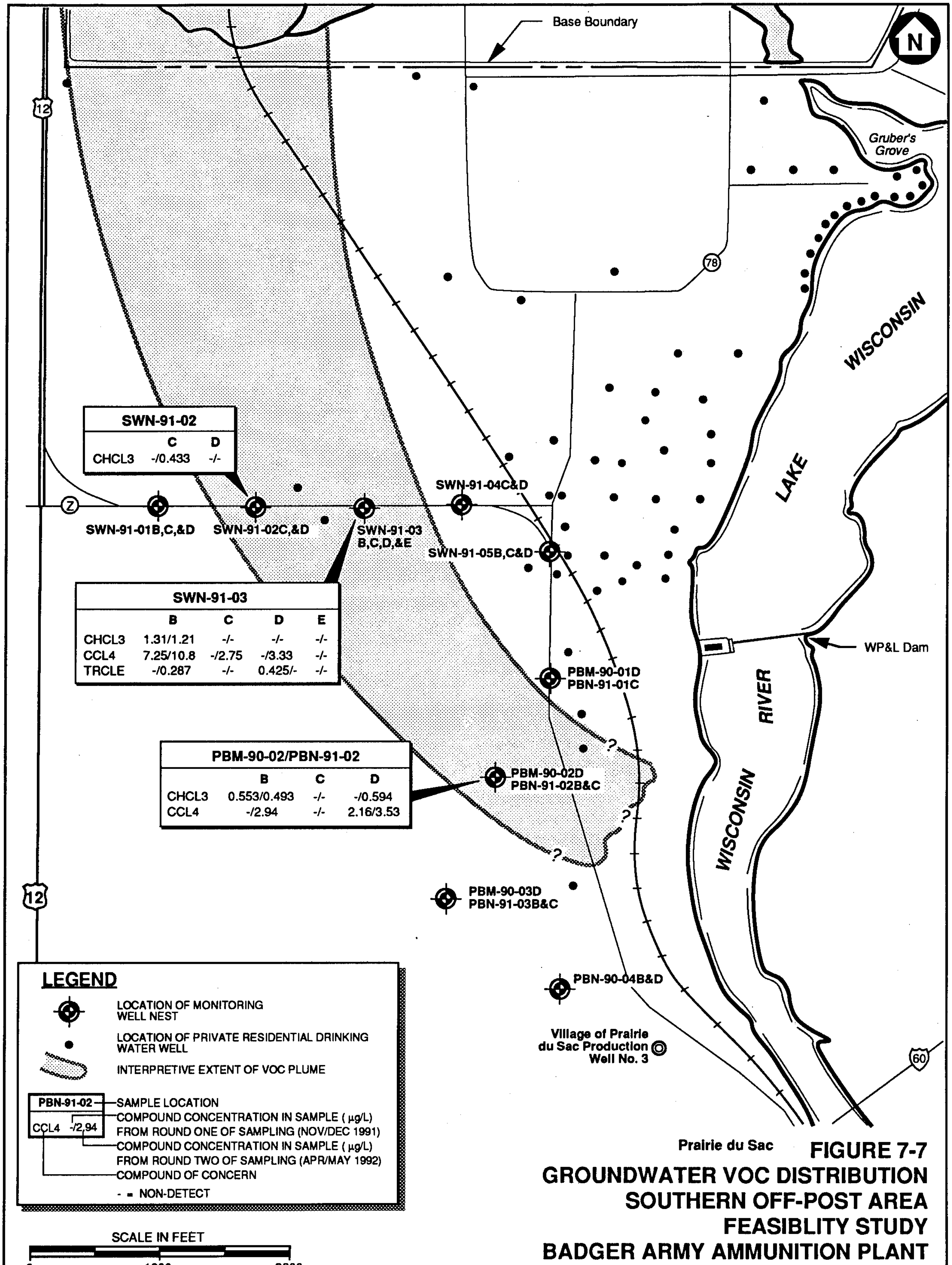


FIGURE 7-7
GROUNDWATER VOC DISTRIBUTION
SOUTHERN OFF-POST AREA
FEASIBLITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9307036D1 3 78

Table 8-1
Summary of Remedial Alternatives Retained for Detailed Evaluation
Soil and Sediment

Feasibility Study
Badger Army Ammunition Plant

Retained Alternative	Propellant Burning Ground	Deterrent Burning Ground	Nitroglycerine Pond/Rocket Paste Area	Settling Ponds and Spoils Disposal Area
Minimal Action	✓	✓	✓	✓
Soil Cover	✓		✓	
Capping	✓			✓
On-Site Incineration and Capping	✓			
On-Site Incineration	✓	✓		
Soil Washing		✓		
Stabilization/Solidification with On-Site Disposal			✓	
In Situ Vacuum Extraction, Soil Washing, Stabilization/Solidification and Soil and Composting	✓		✓	✓
Off-Site Landfill	✓		✓	
Composting and Capping	✓	✓		
In Situ Vacuum Extraction, Composting, and Capping	✓			
In Situ Treatment	✓			
In Situ Vacuum Extraction, Soil Washing, and Composting	✓			

Note:

✓ = Alternative has been retained for detailed evaluation - See report Sections 9.0, 10.0, 11.0, 12.0, and 13.0.

TABLE 8-2
SUMMARY OF REMEDIAL ALTERNATIVES RETAINED FOR DETAILED EVALUATION
SURFACE WATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

RETAINED ALTERNATIVE	NITROGLYCERINE POND/ROCKET PASTE AREA
Minimal Action	✓
Precipitation/Microfiltration	✓
Ion Exchange	✓

Note:

✓ = Alternative has been retained for detailed evaluation - See report Section 11.0.

TABLE 8-3
SUMMARY OF REMEDIAL ALTERNATIVES RETAINED FOR DETAILED EVALUATION GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

RETAINED ALTERNATIVE	PROPELLANT BURNING GROUND	DETERRENT BURNING GROUND	OFF-POST AREA
Minimal Action	✓	✓	✓
Groundwater Extraction, Carbon Adsorption, Discharge	✓	✓	✓
Groundwater Extraction, Air Stripping, Discharge			✓
Groundwater Extraction, Air Stripping - Carbon Adsorption, Discharge	✓	✓	
Groundwater Extraction, Resin Adsorption, Discharge	✓	✓	
Groundwater Extraction, UV Reduction-Carbon Adsorption, Discharge	✓	✓	

Note:

✓ = Alternative has been retained for detailed evaluation - See report Sections 9.0 and 10.0.

TABLE 9-1
COST SUMMARY TABLE
ALTERNATIVE PBG-SS1: MINIMAL ACTION

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF MINIMAL ACTION		
Institutional controls	$	10,000
Fencing & warning signs		74,000
TOTAL DIRECT COST OF MINIMAL ACTION	**$**	**84,000**
INDIRECT COST OF MINIMAL ACTION		
Health and Safety @ 5% of Total Direct Cost	$	4,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		4,000
Engineering @ 10% of Total Direct Cost		8,000
Services During Construction @ 10% of Total Direct Cost		8,000
TOTAL INDIRECT COST OF MINIMAL ACTION	**$**	**24,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**108,000**
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	11,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$**	**169,000**
TOTAL COST OF MINIMAL ACTION	**$**	**277,000**

TABLE 9-2
DETAILED ANALYSIS - ALTERNATIVE PBG-SS1
PROPELLANT BURNING GROUND SURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SS1 MINIMAL ACTION
Overall Protection of Human Health and the Environment	
Human Health Protection	Minimal action does not eliminate or reduce potential risk posed by the soils at the Propellant Burning Ground. This alternative focuses on reducing contaminant exposure by restricting site access.
Environmental Protection	Minimal action does not eliminate or reduce environmental risk posed by the surface soil at the Propellant Burning Ground.
Compliance with ARARs	
Chemical-specific	Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Because soil contaminants would not be removed or destroyed, this alternative would not comply with pathway-specific numeric standards derived from the proposed Chapter NR 720. However, fencing used in this alternative could be designed to achieve a performance standard which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of human health.
Location-specific	RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR - Part 264) may apply. If applicable, a program which incorporates the standards would be implemented. RCRA, Releases from Solid Waste Management Units (Subpart F, 264.90-264.109) may apply for post-closure monitoring of the site. This alternative would include continued groundwater monitoring at the Propellant Burning Ground. Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.
Action-specific	Federal OSHA requirements to protect worker health and safety would be followed during the site work.

continued

TABLE 9-2
DETAILED ANALYSIS - ALTERNATIVE PBG-SS1
PROPELLANT BURNING GROUND SURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SS1 MINIMAL ACTION
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be considered prior to implementation of this alternative.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Under the minimal action alternative, contaminant levels in the soil would not significantly decrease over time. Groundwater quality would continue to be threatened and post-remediation invasive activities could result in significant exposure events.
Adequacy and Reliability of Controls	If managed properly, the combination of controls (i.e., fencing, signs, deed restrictions) should effectively limit public access and use of the site.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Not Applicable. No treatment is used in this alternative.
Amount Destroyed or Treated	No contamination is treated or destroyed.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	Minimal action does not remove or treat contaminants; no reduction of toxicity, mobility, or volume.
Degree to Which Treatment is Irreversible	Not Applicable. No treatment used.
Type and Quantity of Residuals Remaining After Treatment	Not Applicable. No treatment used.
Short-term Effectiveness	
Protection of Community During Remedial Action	Because this alternative provides only minimal actions (i.e., installation of fencing and signs), threats to the community are unlikely to be encountered during implementation.
Protection of Workers During Remedial Action	This alternative provides only minimal action and therefore, threats to site-worker health are unlikely to be encountered during implementation. Workers should follow safe working practices.
Environmental Impacts	There would be no environmental impacts during implementation because there is only minimal action associated with this alternative.
Time Until Remedial Action Objectives Are Achieved	Unknown. All the remedial action objectives may never be achieved with minimal action.

continued

TABLE 9-2
DETAILED ANALYSIS - ALTERNATIVE PBG-SS1
PROPELLANT BURNING GROUND SURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SS1 MINIMAL ACTION
Implementability	
Ability to Construct and Operate the Technology	Installing fencing and posting warning signs at the Propellant Burning Ground are simple construction tasks.
Reliability of the Technology	If fencing is adequately maintained it should be effective in limiting site access.
Ease of Undertaking Additional Remedial Actions, if Necessary	Minimal action would not limit or interfere with the ability to perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	The groundwater monitoring program would adequately monitor contaminant migration.
Ability to Obtain Approvals and Coordinate with Other Agencies	Coordination with appropriate Army officials, WDNR, and the City of Baraboo would be required if these controls are applied. Coordination with Sauk County would be required to implement and maintain a public education program.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Not Applicable.
Availability of Necessary Equipment and Specialists	Local contractors and necessary materials are readily available to erect fencing and warning signs, as well as conduct educational programs.
Availability of Technology	Not Applicable. No technology used.
Costs	
Capital Cost	$108,000
Present Worth of Operation and Maintenance Cost	$169,000
Net Present Worth Cost	$277,000

TABLE 9-3
COST SUMMARY TABLE
ALTERNATIVE PBG-SS2: SOIL COVER

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM	TOTAL COST
DIRECT COST OF SOIL COVER	
Site preparation and mob/demob	$ 235,000
Contaminated soil delineation	147,000
Soil cover	667,000
Surface water management	6,000
Institutional controls	10,000
TOTAL DIRECT COST OF SOIL COVER	**$ 1,065,000**
INDIRECT COST OF SOIL COVER	
Health and Safety @ 5% of Total Direct Cost	$ 53,000
Legal, Administration, Permitting @ 5% of Total Direct Cost	53,000
Engineering @ 10% of Total Direct Cost	107,000
Services During Construction @ 10% of Total Direct Cost	107,000
TOTAL INDIRECT COST OF SOIL COVER	**$ 320,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$ 1,385,000**
OPERATING AND MAINTENANCE COSTS	
Total Annual Post Closure Maintenance Costs	$ 39,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$ 600,000**
TOTAL COST OF SOIL COVER	**$ 1,985,000**

TABLE 9-4
DETAILED ANALYSIS - ALTERNATIVE PBG-SS2
PROPELLANT BURNING GROUND SURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SS2 SOIL COVER
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objective for protection of human health. The soil cover and institutional controls would reduce the potential for human exposure to surface soil with contaminant concentrations greater than remediation goals.
Environmental Protection	Achieves the remedial action objective for terrestrial organisms. The soil cover would reduce the potential for ecological exposure to surface soil with contaminant concentrations greater than remediation goals. The soil cover would not significantly reduce leachate generation and the resultant threat of degrading groundwater quality.
Compliance with ARARs	
Chemical-specific	Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Because soil contaminants would not be removed or destroyed, this alternative would not comply with pathway-specific numeric standards derived from the proposed Chapter NR 720. However, the soil cover used in this alternative could be designed to achieve a performance standard which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of human health.
Location-specific	RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR - Part 264) may apply. If applicable, a program which incorporates the standards would be implemented. RCRA, Releases from Solid Waste Management Units (Subpart F, 264.90-264.109) may apply for post-closure monitoring of the site. This alternative would include continued groundwater monitoring at the Propellant Burning Ground. Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.

continued

TABLE 9-4
DETAILED ANALYSIS - ALTERNATIVE PBG-SS2
PROPELLANT BURNING GROUND SURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SS2 SOIL COVER
Action-specific	Federal OSHA requirements to protect worker health and safety would be followed during site work. Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards. WDNR's Air Management Program will be contacted.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be considered prior to implementation of this alternative.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Provided the soil covers remain intact, residual risk to human and ecological receptors would be negligible. However, post-remediation invasive activities through the soil covers could result in significant exposure events. Because this alternative would not be designed to reduce leachate generation, it would not provide long-term protection of groundwater quality.
Adequacy and Reliability of Controls	Institutional controls would protect the soil covers from invasive activities and restrict residential or public use of the site. Visual inspections would be conducted annually to ensure the integrity of the soil covers. Long-term groundwater monitoring would detect soil contaminants leaching into groundwater.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	No treatment of contaminated soils would occur.
Amount Destroyed or Treated	No treatment of contaminated soils would occur.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	No reduction in the toxicity, mobility, or volume of contaminants. However, natural mobilizing influences such as soil erosion would be reduced.
Degree to Which Treatment is Irreversible	No treatment of contaminated soils would occur.

continued

TABLE 9-4
DETAILED ANALYSIS - ALTERNATIVE PBG-SS2
PROPELLANT BURNING GROUND SURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SS2 SOIL COVER
Type and Quantity of Residuals Remaining After Treatment	No treatment of contaminated soils would occur.
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation. There are no residences close enough to the site to be affected by noise or dust.
Protection of Workers During Remedial Action	With the use of dust suppression techniques and adherence to general health and safety practices, there would be minimal risk to workers.
Environmental Impacts	The Racetrack Area and the Contaminated Waste Area are not considered critical wildlife habitats and the impact to the ecological community is expected to be minor.
Time Until Remedial Action Objectives Are Achieved	The remedial action objective for protection of groundwater would not be achieved. An estimated two to three months would be required to achieve the remedial action objectives for protection of human health and ecological receptors.
Implementability	
Ability to Construct and Operate the Technology	Cover construction can be accomplished using standard construction procedures and conventional earth-moving equipment. Cover repairs would be easily implemented.
Reliability of the Technology	Soil cover is a proven technology for isolating potential receptors from contaminated soil. Institutional controls, annual visual inspections, and soil cover repair (if necessary) would ensure that the integrity of the soil cover is maintained.
Ease of Undertaking Additional Remedial Actions, if Necessary	The soil cover would increase the scope of any future removal actions. If future remedial actions included capping the site to prevent infiltration of precipitation, caps could easily be constructed over the soil covers.
Ability to Monitor Effectiveness of Remedy	Annual visual inspections would be sufficient for monitoring soil cover effectiveness.
Ability to Obtain Approvals and Coordinate with Other Agencies	The integrity of the remedial design would have to be demonstrated to federal and state regulators. Other special permits (e.g., wetland permit) would not be necessary.

continued

TABLE 9-4
DETAILED ANALYSIS - ALTERNATIVE PBG-SS2
PROPELLANT BURNING GROUND SURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SS2 SOIL COVER
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Contaminated soil would not be transported off site.
Availability of Necessary Equipment and Specialists	Obtaining sufficient common borrow soil (i.e., 55,000 cubic yards) and topsoil (i.e., 16,000 cubic yards) in the immediate vicinity of BAAP should not be difficult. Materials may be available within 30 miles of BAAP.
Availability of Technology	A large excavation contracting company could provide the equipment and expertise for constructing soil covers.
Costs	
Capital Cost	$1,385,000
Present Worth of Operation and Maintenance Cost	$600,000
Net Present Worth Cost	$1,985,000

TABLE 9–5
COST SUMMARY TABLE
ALTERNATIVE PBG–SS6: IN SITU S/S AND SOIL COVER

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM	TOTAL COST
DIRECT COST OF IN SITU S/S AND SOIL COVER	
Bench & pilot scale testing	$ 78,000
Site preparation and mob/demob	540,000
Contaminated soil delineation	294,000
In–situ stabilization/solidification inside racetrack and at contaminated waste area	2,137,000
Excavation and placement of soil from outside racetrack	120,000
Stabilization/solidification of soil from outside racetrack with in–situ equipment	1,505,000
Confirmatory analysis	80,000
Soil cover	516,000
Surface water management	6,000
TOTAL DIRECT COST OF IN SITU S/S AND SOIL COVER	$ 5,276,000
INDIRECT COST OF IN SITU S/S AND SOIL COVER	
Health and Safety @ 5% of Total Direct Cost	$ 264,000
Legal, Administration, Permitting @ 5% of Total Direct Cost	264,000
Engineering @ 10% of Total Direct Cost	528,000
Services During Construction @ 10% of Total Direct Cost	528,000
TOTAL INDIRECT COST OF IN SITU S/S AND SOIL COVER	$ 1,584,000
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$ 6,860,000
OPERATING AND MAINTENANCE COSTS	
Total Annual Post Closure Maintenance Costs	$ 31,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	$ 477,000
TOTAL COST OF IN SITU S/S AND SOIL COVER	$ 7,337,000

TABLE 9-6
DETAILED ANALYSIS - ALTERNATIVE PBG-SS6
PROPELLANT BURNING GROUND SURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SS6 MODIFIED IN SITU S/S AND SOIL COVER
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objective for protection of human health. Modified in situ S/S, the soil cover, and institutional controls would reduce the potential for human exposure to contaminant concentrations greater than remediation goals. Stabilized/solidified mass would resist erosion and overland migration of contaminants.
Environmental Protection	Achieves the remedial action objectives for terrestrial organisms and protection of groundwater. Modified in situ S/S and the soil cover would reduce the potential for organism exposure to surface soil with contaminant concentrations greater than remediation goals. Modified in situ S/S would reduce leachate generation such that groundwater is protected.
Compliance with ARARs	
Chemical-specific	Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Because soil contaminants would not be removed or destroyed, this alternative would not comply with pathway-specific numeric standards derived from the proposed Chapter NR 720. However, the modified in situ S/S and soil cover used in this alternative could be designed to achieve a performance standard which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of human health and groundwater.
Location-specific	RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR - Part 264) may apply. If applicable, a program which incorporates the standards would be implemented. RCRA, Releases from Solid Waste Management Units (Subpart F, 264.90-264.109) may apply for post-closure monitoring of the site. This alternative would include continued groundwater monitoring at the Propellant Burning Ground. Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.

continued

TABLE 9-6
DETAILED ANALYSIS - ALTERNATIVE PBG-SS6
PROPELLANT BURNING GROUND SURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SS6 MODIFIED IN SITU S/S AND SOIL COVER
Action-specific	RCRA, Land Disposal Restrictions (LDRs); (40 CFR Part 268) may apply to PB-contaminated soil if it exceeds the TCLP threshold for characteristically hazardous waste. If classified as hazardous, and PB-contaminated soil is excavated, the "characteristic" would have to be removed from the soil prior to disposal or placement on site. Federal OSHA requirements to protect worker health and safety would be followed during the site work. Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards. WDNR's Air Management Program will be contacted.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be considered prior to implementation of this alternative.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Provided the stabilized/solidified treatment residuals and the soil covers remain intact, residual risk to human and ecological receptors would be negligible. In the event construction-related invasive activities occur, or burrowing animals penetrate the soil cover, the chemical and physical properties of the treatment residuals would significantly reduce exposure potential via receptor ingestion and/or inhalation of particulates. Because the treatment residuals would be resistant to degradation processes, they would provide long-term protection of groundwater.
Adequacy and Reliability of Controls	Institutional controls would protect the soil covers from invasive activities and restrict residential or public use of the site. Visual inspections would be conducted annually to ensure the integrity of the soil covers. Long-term groundwater monitoring would detect soil contaminants leaching into groundwater.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	S/S would be used to chemically and physically bind soil contaminants into a stabilized/solidified matrix.

continued

TABLE 9-6
DETAILED ANALYSIS - ALTERNATIVE PBG-SS6
PROPELLANT BURNING GROUND SURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SS6 MODIFIED IN SITU S/S AND SOIL COVER
Amount Destroyed or Treated	An estimated 27,400 cubic yards of surface soil would be treated by in situ S/S inside the Racetrack and at the Contaminated Waste Area. An estimated 18,600 cubic yards of contaminated surface and shallow subsurface soil would be removed from the Burning Pads Area and the Burning Plates Area and treated using in situ S/S equipment inside the Racetrack. Excavation of the Refuse Pits is estimated to result in another 700 cubic yards of contaminated subsurface soil which will undergo treatment inside the Racetrack. Consequently, a total of approximately 46,700 cubic yards of soil would be treated.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	No reduction in contaminant toxicity. Treatment residuals would be resistant to leaching and erosion, preventing the migration of contaminants overland or into groundwater. The volume of contaminated soil would actually increase by up to 50 percent.
Degree to Which Treatment is Irreversible	Treatment is potentially reversible. However, proper maintenance of the soil cover would prevent weathering of the treatment residuals and the release of contaminants.
Type and Quantity of Residuals Remaining After Treatment	Treatment residuals would be a granular or monolithic matrix with entrapped contaminants. The residuals would be buried under a 2.5-foot layer of common borrow and topsoil. Assuming excavation and/or the addition of stabilizing/solidifying agents results in a swell factor of 50 percent, 70,050 cubic yards of residuals would remain on site.
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation. There are no residences close enough to the site to be affected by noise or dust.
Protection of Workers During Remedial Action	With the use of dust suppression techniques and adherence to general health and safety practices, there would be minimal risk to workers.
Environmental Impacts	The Racetrack Area and the Contaminated Waste Area are not considered critical wildlife habitats and the impact to the ecological community is expected to be minor.
Time Until Remedial Action Objectives Are Achieved	An estimated five months are required for treatability studies and another three to four months would be required to achieve the remedial action objectives.

continued

TABLE 9-6
DETAILED ANALYSIS - ALTERNATIVE PBG-SS6
PROPELLANT BURNING GROUND SURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SS6 MODIFIED IN SITU S/S AND SOIL COVER
Implementability	
Ability to Construct and Operate the Technology	Specialized in situ S/S methods have been developed by adapting road construction equipment for that purpose (LaRose, 1993). The even ground surface at the site would be amenable to the use of the equipment. Cover construction can be accomplished using standard construction procedures and conventional earth-moving equipment. Cover repairs would be easily implemented.
Reliability of the Technology	The success of in situ S/S is highly dependent on site- and waste-characteristics. Extensive treatability testing is required. Soil cover is a proven technology for isolating potential receptors from contaminated soil. Annual visual inspections and soil cover repair (if necessary) would ensure that the integrity of the treatment residuals and the soil cover is maintained.
Ease of Undertaking Additional Remedial Actions, if Necessary	Depending upon the physical properties (i.e., granular or monolith) of the treatment residuals, S/S may make future removal actions impractical. If future remedial actions included capping the site to prevent infiltration of precipitation, caps could be constructed over the soil covers.
Ability to Monitor Effectiveness of Remedy	Annual visual inspections would be sufficient for monitoring soil cover effectiveness.
Ability to Obtain Approvals and Coordinate with Other Agencies	The integrity of the remedial design would have to be demonstrated to federal and state regulators. Other special permits (e.g., wetland permit) would not be necessary.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Contaminated soil or treatment residuals would not be transported off site.
Availability of Necessary Equipment and Specialists	Specially-adapted in situ S/S equipment is available from a limited number of vendors. Obtaining sufficient common borrow soil (i.e., 47,700 cubic yards) and topsoil (i.e., 10,300 cubic yards) in the immediate vicinity of BAAP should not be difficult. Materials may be available within 30 miles of BAAP.
Availability of Technology	The technology and expertise for in situ S/S is available from a limited number of vendors. A large excavation contracting company could provide the equipment and expertise for constructing soil covers.

continued

TABLE 9-6
DETAILED ANALYSIS - ALTERNATIVE PBG-SS6
PROPELLANT BURNING GROUND SURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SS6 MODIFIED IN SITU S/S AND SOIL COVER
Costs	
Capital Cost	$6,860,000
Present Worth of Operation and Maintenance Cost	$477,000
Net Present Worth Cost	$7,337,000

Table 9-7
Comparative Summary of Alternatives
Propellant Burning Ground Surface Soil

Feasibility Study
Badger Army Ammunition Plant

Alternative	Overall Protection	Compliance with ARARs	Effectiveness: Long-Term	Reduction in Toxicity, Mobility, and Volume	Effectiveness: Short-Term	Implementability	Cost
Alternative PBG-SS1: Minimal Action	Reduces potential for human exposure to contaminated soil. Not protective of ecological receptors or groundwater.	No chemical-specific ARARs. Although this alternative could meet the intent of the proposed Chapter NR 720 standards for protection of human health, it would not meet the intent of the proposed standards for protection of groundwater.	If managed properly, residual risk to human receptors would be minor. No reduction in residual risk to ecological receptors or threat of groundwater contamination.	Contamination is not treated or destroyed; no reduction of toxicity, mobility, or volume of contaminants.	No adverse community or environmental impacts during implementation.	No implementability concerns.	Total Present Worth: $277,000 Capital Cost: $108,000 Annual O&M: $11,000 (30 yrs)
Alternative PBG-SS2: Soil Cover	Achieves remedial action objectives for protection of human health and ecological receptors. Not protective of groundwater.	No chemical-specific ARARs. Although this alternative could meet the intent of the proposed Chapter NR 720 standards for protection of human health, it would not meet the intent of the proposed standards for protection of groundwater.	If managed properly, residual risk to human and ecological receptors would be negligible. No reduction in threat of groundwater contamination.	No reduction of toxicity, mobility, or volume of contaminants. However, mobilizing influences (e.g., soil erosion) would be reduced.	No adverse impacts to the community and only minimal impact (if general health and safety practices are followed) to workers during implementation. Minor impact to the environment.	No implementability concerns. Soil covers are easily constructed and maintained.	Total Present Worth: $1,985,000 Capital Cost: $1,385,000 Annual O&M: $39,000 (30 yrs)
Modified Alternative PBG-SS6: In Situ S/S and Soil Cover	Achieves remedial action objectives for protection of human health, groundwater, and ecological receptors.	No chemical-specific ARARs. This alternative could meet the intent of the proposed Chapter NR 720 standards for protection of human health and groundwater.	Residual risk to human and ecological receptors would be negligible and the threat of groundwater contamination would be removed.	No reduction of toxicity. Potential mobility would be reduced by S/S. Volume would increase by up to 50 percent.	No adverse impacts to the community and only minimal impact (if general health and safety practices are followed) to workers during implementation. Minor impact to the environment.	Significant implementability concerns. In situ S/S of surface soils is a developing technology and extensive treatability testing is required.	Total Present Worth: $7,337,000 Capital Cost: $6,860,000 Annual O&M: $31,000 (30 yrs)

Notes:

TABLE 9-8
COST SUMMARY TABLE
ALTERNATIVE PBG-SB1: MINIMAL ACTION

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF MINIMAL ACTION		
Institutional controls	$	10,000
TOTAL DIRECT COST OF MINIMAL ACTION	**$**	**10,000**
INDIRECT COST OF MINIMAL ACTION		
Health and Safety @ 0% of Total Direct Cost	$	0
Legal, Administration, Permitting @ 0% of Total Direct Cost		0
Engineering @ 0% of Total Direct Cost		0
Services During Construction @ 0% of Total Direct Cost		0
TOTAL INDIRECT COST OF MINIMAL ACTION	**$**	**0**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**10,000**
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	7,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$**	**108,000**
TOTAL COST OF MINIMAL ACTION	**$**	**118,000**

Table 9-9
Detailed Analysis - Alternative PBG-SB1
Propellant Burning Ground Subsurface Soils

Feasibility Study
Badger Army Ammunition Plant

Evaluation Criteria	Alternative PBG-SB1 Minimal Action
Overall Protection of Human Health and the Environment	
Human Health Protection	Minimal action does not eliminate or reduce potential risk posed by the subsurface soils at the Propellant Burning Ground. This alternative focuses on reducing contaminant exposure by restricting site access through the use of institutional controls.
Environmental Protection	Although there is no ecological risk associated with subsurface soils at the Propellant Burning Ground, there is a threat of groundwater contamination. Minimal action does not eliminate or reduce the threat of groundwater contamination.
Compliance with ARARs	
Chemical-specific	Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Because soil contaminants would not be removed or destroyed, this alternative would not comply with pathway-specific numeric standards derived from the proposed Chapter NR 720. No remedial actions designed to achieve a performance standard which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of human health or groundwater would be implemented.
Location-specific	RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR - Part 264) may apply. If applicable, a program which incorporates the standards would be implemented. RCRA, Releases from Solid Waste Management Units (Subpart F, 264.90-264.109) may apply for post-closure monitoring of the site. This alternative would include continued groundwater monitoring at the Propellant Burning Ground. Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.

continued

Table 9-9
Detailed Analysis - Alternative PBG-SB1
Propellant Burning Ground Subsurface Soils

Feasibility Study
Badger Army Ammunition Plant

Evaluation Criteria	Alternative PBG-SB1 Minimal Action
Action-specific	Federal OSHA requirements to protect worker health and safety would be followed during the site work.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be considered prior to implementation of this alternative.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Under the minimal action alternative, contaminant levels in the soil would not decrease significantly over time. Groundwater quality would continue to be threatened and invasive activities could result in significant exposure events.
Adequacy and Reliability of Controls	If managed properly, the combination of controls and educational programs should effectively limit public access and use of the site.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Not applicable. No treatment is used in this alternative.
Amount Destroyed or Treated	There would be no contaminants destroyed or treated.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	Minimal action does not employ removal or treatment processes to address soil contamination; no reduction in toxicity, mobility, or volume of contaminated subsurface soils would be achieved.
Degree to Which Treatment is Irreversible	Not Applicable. No treatment is used with this alternative.
Type and Quantity of Residuals Remaining After Treatment	Not Applicable. No treatment is used with this alternative.
Short-term Effectiveness	
Protection of Community During Remedial Action	Because this alternative does not involve construction, threats to the community are unlikely to be encountered during implementation.
Protection of Workers During Remedial Action	This alternative does not involve any construction activities and therefore no site workers would be affected during implementation.
Environmental Impacts	No impacts to the environment should be encountered during implementation.

continued

TABLE 9-9
DETAILED ANALYSIS - ALTERNATIVE PBG-SB1
PROPELLANT BURNING GROUND SUBSURFACE SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SB1 MINIMAL ACTION
Time Until Remedial Action Objectives Are Achieved	Unknown. All the remedial action objectives may never be achieved with minimal action.
Implementability	
Ability to Construct and Operate the Technology	Not Applicable. No construction is necessary with this alternative.
Reliability of the Technology	Not Applicable. No technology is used with this alternative.
Ease of Undertaking Additional Remedial Actions, if Necessary	Minimal action would not limit or interfere with the ability to perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	The groundwater monitoring program would adequately monitor contaminant migration.
Ability to Obtain Approvals and Coordinate with Other Agencies	Coordination with the Army, WDNR, and the City of Baraboo would be required if these controls are applied. Coordination with Sauk County would be required to implement and maintain a public education program.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Not Applicable.
Availability of Necessary Equipment and Specialists	Local contractors are readily available to conduct education programs.
Availability of Technology	Not Applicable. No technology used.
Costs	
Capital Cost	\$10,000
Present Worth of Operation and Maintenance Cost	\$108,000
Net Present Worth Cost	\$118,000

TABLE 9-10
COST SUMMARY TABLE
ALTERNATIVE PBG-SB2: CAPPING

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF CAPPING		
Site preparation and mob/demob	$	198,000
Roadway improvement		22,000
Contaminated soil delineation		80,000
Cap construction		654,000
Institutional controls		10,000
TOTAL DIRECT COST OF CAPPING	**$**	**964,000**
INDIRECT COST OF CAPPING		
Health and Safety @ 5% of Total Direct Cost	$	48,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		48,000
Engineering @ 10% of Total Direct Cost		96,000
Services During Construction @ 10% of Total Direct Cost		96,000
TOTAL INDIRECT COST OF CAPPING	**$**	**288,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**1,252,000**
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	7,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$**	**108,000**
TOTAL COST OF CAPPING	**$**	**1,360,000**

TABLE 9-11
DETAILED ANALYSIS - ALTERNATIVE PBG-SB2
PROPELLANT BURNING GROUND SUBSURFACE SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SB2 CAPPING
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objective for protection of human health. The RCRA cap and institutional controls would reduce the potential for human exposure to subsurface soil with contaminant concentrations greater than remediation goals.
Environmental Protection	No ecological risk associated with contaminated subsurface soil. The RCRA caps would reduce leachate generation such that groundwater is protected.
Compliance with ARARs	
Chemical-specific	Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Because soil contaminants would not be removed or destroyed, this alternative would not comply with pathway-specific numeric standards derived from the proposed Chapter NR 720. However, the RCRA caps used in this alternative could be designed to achieve a performance standard which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of human health and groundwater.
Location-specific	RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR - Part 264) may apply. If applicable, a program which incorporates the standards would be implemented. RCRA, Releases from Solid Waste Management Units (Subpart F, 264.90-264.109) may apply for post-closure monitoring of the site. This alternative would include continued groundwater monitoring at the Propellant Burning Ground. Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.

continued

TABLE 9-11
DETAILED ANALYSIS - ALTERNATIVE PBG-SB2
PROPELLANT BURNING GROUND SUBSURFACE SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SB2 CAPPING
Action-specific	Federal OSHA requirements to protect worker health and safety would be followed during the site work. Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards. WDNR's Air Management Program will be contacted.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be considered prior to implementation of this alternative.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Provided the RCRA caps remain intact, residual risk to human receptors and the threat of groundwater contamination would be negligible. Post-remediation invasive activities through the caps could result in significant exposure events and cause leachate generation and associated degradation of groundwater quality.
Adequacy and Reliability of Controls	Institutional controls would protect the caps from invasive activities and restrict residential or public use of the site. Visual inspections would be conducted annually to ensure the integrity of the caps. Long-term groundwater monitoring would detect soil contaminants leaching into groundwater.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	No treatment of contaminated soils would occur.
Amount Destroyed or Treated	No treatment of contaminated soils would occur.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	No reduction in the toxicity, mobility, or volume of contaminants. However, natural mobilizing influences such as infiltration of precipitation and associated leachate generation would be reduced.
Degree to Which Treatment is Irreversible	No treatment of contaminated soils would occur.

Table 9-11
Detailed Analysis - Alternative PBG-SB2
Propellant Burning Ground Subsurface Soils

Feasibility Study
Badger Army Ammunition Plant

Evaluation Criteria	Alternative PBG-SB2 Capping
Type and Quantity of Residuals Remaining After Treatment	No treatment of contaminated soils would occur.
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation. There are no residences close enough to the site to be affected by noise or dust.
Protection of Workers During Remedial Action	With the use of dust suppression techniques and adherence to general health and safety practices, there would be minimal risk to workers.
Environmental Impacts	The 1949 Pit and Landfill 1 are not considered critical wildlife habitats and the impact to the ecological community is expected to be minor.
Time Until Remedial Action Objectives Are Achieved	An estimated two to three months would be required to achieve the remedial action objectives.
Implementability	
Ability to Construct and Operate the Technology	RCRA cap construction can be accomplished using standard construction procedures and conventional earth-moving equipment. Cap repairs would be easily implemented.
Reliability of the Technology	Capping is a proven technology for reducing leachate generation and is generally the prescribed method for landfill closure.
Ease of Undertaking Additional Remedial Actions, if Necessary	Capping would increase the scope of any future removal actions.
Ability to Monitor Effectiveness of Remedy	Annual visual inspections and groundwater monitoring would be sufficient for monitoring cap effectiveness.
Ability to Obtain Approvals and Coordinate with Other Agencies	The integrity of the remedial design would have to be demonstrated to federal and state regulators. Other special permits (e.g., wetland permit) would not be necessary.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Contaminated soil would not be transported off site.

continued

TABLE 9-11
DETAILED ANALYSIS - ALTERNATIVE PBG-SB2
PROPELLANT BURNING GROUND SUBSURFACE SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SB2 CAPPING
Availability of Necessary Equipment and Specialists	Obtaining sufficient quantities of clay, sand, common borrow soil, and topsoil in the immediate vicinity of BAAP should not be difficult. Materials may be available within 30 miles of BAAP.
Availability of Technology	A large excavation contracting company with experience in landfill construction/closure could provide the equipment and expertise for constructing the caps.
Costs	
Capital Cost	$1,252,000
Present Worth of Operation and Maintenance Cost	$108,000
Present Worth Cost	$1,360,000

TABLE 9-12
COST SUMMARY TABLE
ALTERNATIVE PBG-SB3: OFF-SITE LANDFILL

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM	TOTAL COST
DIRECT COST OF OFF-SITE LANDFILL	
Site preparation and mob/demob	$ 208,000
Roadway improvement	22,000
Delineation of soil contamination	116,000
Excavation, transportation, disposal, and backfill	1,841,000
TOTAL DIRECT COST OF OFF-SITE LANDFILL	**$ 2,187,000**
INDIRECT COST OF OFF-SITE LANDFILL	
Health and Safety @ 5% of Total Direct Cost	$ 109,000
Legal, Administration, Permitting @ 5% of Total Direct Cost	109,000
Engineering @ 10% of Total Direct Cost	219,000
Services During Construction @ 10% of Total Direct Cost	219,000
TOTAL INDIRECT COST OF OFF-SITE LANDFILL	**$ 656,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$ 2,843,000**
OPERATING AND MAINTENANCE COSTS	
Total Annual Operating and Maintenance Costs	$ 0
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$ 0**
TOTAL COST OF OFF-SITE LANDFILL	**$ 2,843,000**

TABLE 9-13
DETAILED ANALYSIS - ALTERNATIVE PBG-SB3
PROPELLANT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SB3 OFF-SITE LANDFILL
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objective for protection of human health. Soil removal would eliminate the potential for human exposure to contaminant concentrations greater than remediation goals.
Environmental Protection	No ecological risks associated with contaminated subsurface soil. Achieves the remedial action objective for protection of groundwater. Soil removal would eliminate leachate generation and the associated threat of groundwater contamination.
Compliance with ARARs	
Chemical-specific	Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Because soil contaminants would be removed from Landfill 1 and the 1949 Pit, this alternative would comply with pathway-specific numeric standards derived from the proposed Chapter NR 720.
Location-specific	No location-specific ARARS.

continued

TABLE 9-13
DETAILED ANALYSIS - ALTERNATIVE PBG-SB3
PROPELLANT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SB3 OFF-SITE LANDFILL
Action-specific	Federal OSHA requirements to protect worker health and safety would be followed during the site work. Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards. WDNR's Air Management Program will be contacted. The following action-specific ARARs would apply to the contaminated soil transporter and the receiving off-site landfill: DOT Rule for Transportation of Hazardous Materials; (49 CFR Parts 107, 171.1-172.558) Standards Applicable to Transporter of Hazardous Waste, RCRA Section 3003; (40 CFR 170-179) RCRA, Land Disposal Restrictions (LDRs); (40 CFR Part 268). May apply to PB-contaminated soil if it exceeds the TCLP threshold for characteristically hazardous waste. If classified as hazardous, and PB-contaminated soil is excavated, the "characteristic" would have to be removed from the soil prior to disposal. RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities; (40 CFR - Part 264) <u>or</u> WAC Chapter NR 600 and WAC Chapter NR 660
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be considered prior to implementation of this alternative.

continued

TABLE 9-13
DETAILED ANALYSIS - ALTERNATIVE PBG-SB3
PROPELLANT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SB3 OFF-SITE LANDFILL
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	No residual risk at Landfill 1 and the 1949 Pit because the contaminated soil would be removed.
Adequacy and Reliability of Controls	The off-site landfill must be properly managed to ensure contaminants are isolated from potential receptors and that groundwater quality is not threatened.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Treatment of contaminated soil may occur at the receiving off-site landfill. If treatment occurred, the landfill operator would likely treat the soil by S/S prior to disposal.
Amount Destroyed or Treated	Approximately 2,650 cubic yards of contaminated soil would be removed from the 1949 Pit and 1,400 cubic yards from Landfill 1. Assuming the landfill operator treated all of the soil by S/S, a total of 4,050 cubic yards (not accounting for swell) of soil would be treated.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	No reduction in contaminant toxicity. If treated by S/S, the landfilled soil would be resistant to leaching, preventing the migration of contaminants into groundwater. Additionally, the landfill would be designed to contain and isolate the soil from environmental media and receptors. The volume of contaminated soil would actually increase by up to 50 percent.
Degree to Which Treatment is Irreversible	Treatment is potentially reversible. However, proper operation of the receiving landfill would prevent weathering of solidified material and the release of contaminants.
Type and Quantity of Residuals Remaining After Treatment	No treatment residuals would be present in the 1949 Pit or Landfill 1. Treatment residuals at the receiving landfill would likely consist of monolithic blocks of solidified material. Assuming excavation and the addition of stabilizing/solidifying agents results in a swell factor of 50 percent, 6,075 cubic yards of treatment residuals would be landfilled.
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation. There are no residences close enough to the site to be affected by noise or dust.

continued

TABLE 9-13
DETAILED ANALYSIS - ALTERNATIVE PBG-SB3
PROPELLANT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SB3 OFF-SITE LANDFILL
Protection of Workers During Remedial Action	With the use of dust suppression techniques and adherence to general health and safety practices, there would be minimal risk to workers.
Environmental Impacts	The 1949 Pit and Landfill 1 are not considered critical wildlife habitats and the impact to the ecological community is expected to be minor.
Time Until Remedial Action Objectives Are Achieved	An estimated two to three months would be required to achieve the remedial action objectives.
Implementability	
Ability to Construct and Operate the Technology	Soil removal can be accomplished using standard excavation procedures and conventional earth-moving equipment. RCRA-permitted off-site landfills in the region do not presently experience operating difficulties.
Reliability of the Technology	Off-site landfill is a demonstrated technology for disposal of hazardous waste.
Ease of Undertaking Additional Remedial Actions, if Necessary	Future remedial actions, including soil removal or capping, could be easily implemented.
Ability to Monitor Effectiveness of Remedy	No monitoring would be required at the 1949 Pit or Landfill 1. In accordance with their operating permit, the receiving landfill would provide long-term monitoring for releases from their facility.
Ability to Obtain Approvals and Coordinate with Other Agencies	Special permits (e.g, wetland permit) would not be necessary and obtaining approval for soil removal should not be difficult.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	An off-site landfill with sufficient capacity and permitted for treatment and disposal of hazardous waste is located 108 miles from BAAP (i.e., Menomonee Falls, WI).
Availability of Necessary Equipment and Specialists	Local excavation and transportation contractors can provide the necessary equipment and expertise for soil removal and transport to the off-site landfill. The off-site landfill would provide S/S services.
Availability of Technology	S/S and disposal services would be available at the receiving landfill.

continued

TABLE 9-13
DETAILED ANALYSIS - ALTERNATIVE PBG-SB3
PROPELLANT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-SB3 OFF-SITE LANDFILL
Costs	
Capital Cost	$2,843,000
Present Worth of Operation and Maintenance Cost	$0
Net Present Worth Cost	$2,843,000

Table 9-14
Comparative Summary of Subsurface Soil Alternatives
Propellant Burning Ground Subsurface Soil

Feasibility Study
Badger Army Ammunition Plant

Alternative	Overall Protection	Compliance with ARARs	Effectiveness: Long-Term	Reduction in Toxicity, Mobility, and Volume	Effectiveness: Short-Term	Implementability	Cost
Alternative PBG-SB1: Minimal Action	Reduces potential for human exposure to contaminated soil. Not protective of groundwater.	No chemical-specific ARARs. This alternative would not meet the intent of the proposed Chapter NR 720 standards for protection of human health and groundwater.	If managed properly, residual risk to human receptors would be minor. No reduction in the threat of ground-water contamination.	Contamination is not treated or destroyed; no reduction of toxicity, mobility, or volume of contaminants.	No adverse community or environmental impacts during implementation.	No implementability concerns.	Total Present Worth: $118,000 Capital Cost: $10,000 Annual O&M: $7,000 (30 yrs)
Alternative PBG-SB2: Capping	High potential for achieving remedial action objectives for protection of human health and groundwater.	No chemical-specific ARARs. This alternative could meet the intent of the proposed Chapter NR 720 standards for protection of human health and groundwater.	If managed properly, residual risk to human receptors and the threat of groundwater contamination would be negligible.	No reduction of toxicity, mobility, or volume of contaminants. However, mobilizing influences (e.g., infiltration of precipitation) would be reduced.	No adverse impacts to the community and only minimal (if general health and safety practices are followed) to workers during implemen-tation.	No implementability concerns. RCRA caps are easily constructed and maintained.	Total Present Worth: $1,360,000 Capital Cost: $1,252,000 Annual O&M: $7,000 (30 yrs)
Alternative PBG-SB3: Off-Site Landfill	Achieves remedial action objectives for protection of human health and groundwater.	No chemical-specific ARARs. This alternative would comply with pathway-specific numeric standards derived from the proposed Chapter NR 720.	No residual risk at Landfill 1 and the 1949 Pit. If managed properly, residual risk at receiving off-site landfill would be negligible.	S/S may occur at the off-site landfill prior to disposal. S/S would not reduce toxicity but would reduce potential mobility. Volume would increase by up to 50 percent.	No adverse impacts to the community and only minimal (if general health and safety practices are followed) to workers during implemen-tation.	No implementability concerns. Excavation and disposal in an off-site landfill would be easily implemented.	Total Present Worth: $2,843,000 Capital Cost: $2,843,000 Annual O&M: $0

Notes:

TABLE 9-15
COST SUMMARY TABLE
ALTERNATIVE PBG-WP1: MINIMAL ACTION

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF MINIMAL ACTION		
Institutional controls	$	10,000
TOTAL DIRECT COST OF MINIMAL ACTION	$	10,000
INDIRECT COST OF MINIMAL ACTION		
Health and Safety @ 0% of Total Direct Cost	$	0
Legal, Administration, Permitting @ 0% of Total Direct Cost		0
Engineering @ 0% of Total Direct Cost		0
Services During Construction @ 0% of Total Direct Cost		0
TOTAL INDIRECT COST OF MINIMAL ACTION	$	0
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$	10,000
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	6,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	$	92,000
TOTAL COST FOR MINIMAL ACTION	$	102,000

TABLE 9-16
DETAILED ANALYSIS - ALTERNATIVE PBG-WP1
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP1 MINIMAL ACTION
Overall Protection of Human Health and the Environment	
Human Health Protection	Minimal action does not eliminate or reduce potential risk posed by the waste pit soils at the Propellant Burning Ground. This alternative focuses on reducing contaminant exposure by restricting site access through the use of institutional controls.
Environmental Protection	Although there is no ecological risk associated with subsurface soils at the Waste Pits, there is a threat of groundwater contamination. Minimal action does not eliminate or reduce the threat of groundwater contamination.
Compliance with ARARs	
Chemical-specific	Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Because soil contaminants would not be removed or destroyed, this alternative would not comply with pathway-specific numeric standards derived from the proposed Chapter NR 720. No remedial actions designed to achieve a performance standard which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of human health or groundwater would be implemented.
Location-specific	RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR - Part 264) may apply. If applicable, a program which incorporates the standards would be implemented. RCRA, Releases from Solid Waste Management Units (Subpart F, 264.90-264.109) may apply for post-closure monitoring of the site. This alternative would include continued groundwater monitoring at the Propellant Burning Ground. Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.

TABLE 9-16
DETAILED ANALYSIS - ALTERNATIVE PBG-WP1
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP1 MINIMAL ACTION
Action-specific	Federal OSHA requirements to protect worker health and safety would be followed during the site work.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be considered prior to implementation of this alternative.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Under the minimal action alternative, contaminant levels in the soil would not significantly decrease over time.
Adequacy and Reliability of Controls	If managed properly, the combination of controls (i.e., zoning and deed restrictions) should effectively limit the use of the site.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Not Applicable. No treatment is used in this alternative.
Amount Destroyed or Treated	No contamination is treated or destroyed.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	No reduction of toxicity, mobility, or volume.
Degree to Which Treatment is Irreversible	Not Applicable. No treatment used.
Type and Quantity of Residuals Remaining After Treatment	Not Applicable. No treatment used.
Short-term Effectiveness	
Protection of Community During Remedial Action	Because this alternative provides only a minimal response action (i.e., zoning and deed restrictions), threats to the community would not be encountered during implementation.
Protection of Workers During Remedial Action	This alternative provides only a minimal response action which does not require any construction. However site workers involved in the groundwater monitoring program should follow safe working practices.
Environmental Impacts	There would be no environmental impacts during implementation.
Time Until Remedial Action Objectives Are Achieved	Unknown. All remedial action objectives may never be achieved with minimal action.

continued

TABLE 9-16
DETAILED ANALYSIS - ALTERNATIVE PBG-WP1
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP1 MINIMAL ACTION
Implementability	
Ability to Construct and Operate the Technology	Not Applicable. No construction is associated with this alternative.
Reliability of the Technology	Not Applicable. No technology is used with this alternative.
Ease of Undertaking Additional Remedial Actions, if Necessary	Minimal action would not limit or interfere with the ability to perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	The groundwater monitoring program would adequately monitor contaminant migration.
Ability to Obtain Approvals and Coordinate with Other Agencies	Coordination with appropriate Army officials, WDNR, and the City of Baraboo would be required if these controls are applied. Coordination with Sauk County would be required to implement and maintain a public education program.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Not Applicable.
Availability of Necessary Equipment and Specialists	Local contractors are readily available to conduct educational programs.
Availability of Technology	Not Applicable. No technology used.
Costs	
Capital Cost	$10,000
Present Worth of Operation and Maintenance Cost	$108,000
Net Present Worth Cost	$118,000

TABLE 9-17
COST SUMMARY TABLE
ALTERNATIVE PBG-WP4: ON-SITE INCINERATION AND CAPPING

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF ON-SITE INCINERATION AND CAPPING		
Site preparation and mob/demob	$	2,415,000
Contaminated soil delineation		138,000
Excavate, blend, and screen contaminated soil		401,000
Backfill soil		209,000
Incineration		1,832,000
Cap construction		138,000
Institutional controls		10,000
TOTAL DIRECT COST OF ON-SITE INCINERATION AND CAPPING	$	5,143,000
INDIRECT COST OF ON-SITE INCINERATION AND CAPPING		
Health and Safety @ 5% of Total Direct Cost	$	257,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		257,000
Engineering @ 10% of Total Direct Cost		514,000
Services During Construction @ 10% of Total Direct Cost		514,000
TOTAL INDIRECT COST OF ON-SITE INCINERATION AND CAPPING	$	1,542,000
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$	6,685,000
OPERATING AND MAINTENANCE COSTS		
Total Annual Post Closure Maintenance Costs	$	7,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	$	108,000
TOTAL COST OF ON-SITE INCINERATION AND CAPPING	$	6,793,000

TABLE 9-18
DETAILED ANALYSIS - ALTERNATIVE PBG-WP4
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP4 ON-SITE INCINERATION AND CAPPING
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objective for protection of human health. Incineration of severely contaminated soil, the RCRA caps, and institutional controls would eliminate the potential for human exposure to waste pit soil with contaminant concentrations greater than remediation goals.
Environmental Protection	No ecological risks associated with contaminated waste pit soil. Although the waste pit caps would be designed to prevent infiltration of precipitation, a large quantity of contaminants would remain close to the groundwater table in waste pit soils and would continue to present a threat to groundwater quality. VOCs could migrate out from under the caps via volatilization and lateral transport of vapors. Ensuing precipitation could then transport the VOCs to the groundwater table.
Compliance with ARARs	
Chemical-specific	Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Although excavation and treatment of severely contaminated soil would achieve pathway-specific numeric standards for protection of human health and groundwater, the unexcavated soil would not comply with pathway-specific numeric standards. The RCRA caps used in this alternative could be designed to achieve a performance standard for SVOC-contaminated soil which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of groundwater; however, the RCRA caps could not be designed to achieve a performance standard for unexcavated VOC-contaminated soil.
Location-specific	The following location-specific ARARs may apply to contaminants remaining on site: RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities; (40 CFR - Part 264) <u>or</u> WAC Chapter NR 600 RCRA, Releases from Solid Waste Management Units (Subpart F, 264.90-264.109) may apply for post-closure monitoring of the site. This alternative would include continued groundwater monitoring at the Propellant Burning Ground.

continued

TABLE 9-18
DETAILED ANALYSIS - ALTERNATIVE PBG-WP4
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP4 ON-SITE INCINERATION AND CAPPING
	Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.
Action-specific	RCRA, Land Disposal Restrictions (LDRs); (40 CFR Part 268) may apply to C6H6 waste disposed of in the waste pits. The C6H6 waste has been identified as a listed hazardous waste from non-specific sources (i.e., F005), per 40 CFR Part 261.31. As such, C6H6-contaminated soil may be subject to LDRs and, if excavated, must be treated so that it no longer "contains" C6H6 or treated to a concentration level prior to disposal in a RCRA Subtitle C permitted facility. In addition, 24DNT-contaminated soil in the waste pits would be characteristically hazardous if it exceeds the TCLP threshold for 24DNT waste. If classified as hazardous, and 24DNT-contaminated soil is excavated, the "characteristic" would have to be removed from the soil prior to disposal or placement on site. It is presumed that on-site incineration would comply with all RCRA requirements for hazardous waste incinerators (40 CFR Subpart O), and all applicable Clean Air Act requirements (40 CFR 50, 52, 60, and 61). Federal OSHA requirements to protect worker health and safety would be followed during any site work. Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards. WDNR's Air Management Program will be contacted.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be considered prior to implementation of this alternative.

continued

TABLE 9-18
DETAILED ANALYSIS - ALTERNATIVE PBG-WP4
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP4 ON-SITE INCINERATION AND CAPPING
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Because the severely contaminated soil would be excavated and incinerated, residual risk to human receptors would be negligible. Although the caps would limit natural mobilizing influences (i.e., infiltrating precipitation) on contaminants remaining in waste pit soils, the large quantity of contaminants and the inherent mobility of VOCs in the unsaturated zone would pose a long-term threat to groundwater quality.
Adequacy and Reliability of Controls	Institutional controls would protect the caps from invasive activities and restrict residential or public use of the site. Visual inspections would be conducted annually to ensure the integrity of the caps. Long-term groundwater monitoring would detect soil contaminants leaching into groundwater.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	On-site incineration would destroy waste pit soil contaminants via thermal oxidation.
Amount Destroyed or Treated	Approximately 3,750 cubic yards of contaminated soil would be incinerated (approximately 1,250 cubic yards per pit). Assuming an average DNT (primary waste pit contaminant) concentration of 20,000 mg/kg, approximately 55,500 pounds of DNTs would be destroyed. Accounting for a small quantity of VOCs in waste pit soils, a total of approximately 56,000 pounds of waste pit contaminants would be destroyed.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	The incinerator would be permitted and operated to achieve a destruction and removal efficiency of at least 99.9999 percent. The toxicity, mobility, and volume of the remaining waste pit contaminants would not be reduced but natural mobilizing influences (i.e., infiltrating precipitation) would be limited by the caps.
Degree to Which Treatment is Irreversible	Contaminants in the excavated soil would be destroyed by incineration. Remaining waste pit contaminants would not be treated.

continued

TABLE 9-18
DETAILED ANALYSIS - ALTERNATIVE PBG-WP4
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP4 ON-SITE INCINERATION AND CAPPING
Type and Quantity of Residuals Remaining After Treatment	Bottom ash (i.e., treated soil), fly ash, and wastewater would be generated during incineration. Treated soil would be backfilled into the excavations. Fly ash, approximately 10 percent (i.e., 375 cubic yards) of the total volume treated, would transported to an off-site landfill for disposal. Wastewater would be treated on site with auxiliary equipment.
Short-term Effectiveness	
Protection of Community During Remedial Action	Although the incinerator would destroy and remove 99.9999 percent of the contaminants in the feed material per the operating permit, air emissions could contain traces of contaminants. However, the incinerator would be operating in a isolated portion of BAAP (i.e., Contaminated Waste Area) and no residences or active BAAP facilities are present within a mile of the site. Modeling of emission dispersal, as is normally conducted prior to permitting incinerators, is expected to indicate that the risk to human receptors downwind of the incinerator is minor.
Protection of Workers During Remedial Action	Air monitoring would be conducted at the site during excavation and incineration activities. Not only is there ingestion/inhalation risk associated with VOC- and DNT-contaminated soil but there is a reactive (i.e., DNT concentrations greater than 10 percent) risk. Special precautions may be required during excavation to prevent an explosive reaction. OSHA and other health and safety requirements which limit worker exposure to inhalation hazards would be enforced. If activities resulted in unacceptable levels of air contaminants, operations would be modified to protect workers.
Environmental Impacts	The Contaminated Waste Area is not considered a critical wildlife habitat and the impact to the ecological community during soil excavation and cap construction is expected to be minor. Potential impacts to ecological receptors from incinerator emissions are difficult to estimate but concentrations and the associated risk in the vicinity of the incinerator are expected to be low.

continued

TABLE 9-18
DETAILED ANALYSIS - ALTERNATIVE PBG-WP4
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP4 ON-SITE INCINERATION AND CAPPING
Time Until Remedial Action Objectives Are Achieved	It is doubtful that the remedial action objective for protection of groundwater would be achieved. An estimated 9 to 12 months would be required for trial burns and permitting and another 9 to 12 months would be required for trial burns and permitting and another 9 to 12 months would be required to achieve the remedial action objective for protection of human health.
Implementability	
Ability to Construct and Operate the Technology	Transportable incinerators are available which can be mobilized to the site and operated using contractor-furnished personnel. Cap construction can be accomplished using standard construction procedures and conventional earth-moving equipment. Cap repairs would be easily implemented.
Reliability of the Technology	Incineration is the most effective and proven method for destruction of explosive-contaminated soil. Capping is a proven technology for reducing infiltration of precipitation and the resultant formation of leachate in contaminated soil. Annual visual inspections and cap repair (if necessary) would ensure that the integrity of the caps is maintained.
Ease of Undertaking Additional Remedial Actions, if Necessary	The caps would increase the scope of any future soil excavation and/or treatment. The caps would have to be dismantled if soil removal or in situ soil treatment methods were implemented.
Ability to Monitor Effectiveness of Remedy	Groundwater monitoring will determine cap effectiveness for preventing groundwater contamination.
Ability to Obtain Approvals and Coordinate with Other Agencies	The process for permitting an incinerator could be long and difficult. Extensive modeling of incinerator emissions may be required to show that potential receptors are not at risk. The integrity of cap design would have to be demonstrated to federal and state regulators. Other special permits (e.g., wetland permit) would not be necessary.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Fly ash (approximately 375 cubic yards) would be transported off site for disposal. An off-site landfill permitted for treatment and disposal of hazardous waste is located 108 miles from BAAP (i.e., Menomonee Falls, WI).

continued

TABLE 9-18
DETAILED ANALYSIS - ALTERNATIVE PBG-WP4
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP4 ON-SITE INCINERATION AND CAPPING
Availability of Necessary Equipment and Specialists	Several vendors capable of providing incineration equipment and trained personnel are available. Obtaining sufficient clay, sand, common borrow soil, and topsoil in the vicinity of BAAP for cap construction should not be difficult.
Availability of Technology	Incineration equipment previously used for treatment of explosive-contaminated soil is available. A large excavation contracting company could provide the equipment and the expertise for constructing the caps.
Costs	
Capital Cost	$6,685,000
Present Worth of Operation and Maintenance Cost	$108,000
Net Present Worth Cost	$6,793,000

TABLE 9-19
COST SUMMARY TABLE
ALTERNATIVE PBG-WP5: COMPOSTING AND CAPPING

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
<u>DIRECT COST OF COMPOSTING AND CAPPING</u>		
Treatability testing	$	30,000
Site preparation and mob/demob		719,000
Contaminated soil delineation		138,000
Excavate, blend, and screen contaminated soil		401,000
Backfill soil		209,000
Composting		1,600,000
Cap construction		138,000
Institutional controls		10,000
TOTAL DIRECT COST OF COMPOSTING AND CAPPING	$	3,245,000
<u>INDIRECT COST OF COMPOSTING AND CAPPING</u>		
Health and Safety @ 5% of Total Direct Cost	$	162,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		162,000
Engineering @ 10% of Total Direct Cost		325,000
Services During Construction @ 10% of Total Direct Cost		325,000
TOTAL INDIRECT COST OF COMPOSTING AND CAPPING	$	974,000
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$	4,219,000
<u>OPERATING AND MAINTENANCE COSTS</u>		
O&M of Composting System for 1 Year	$	1,085,000
TOTAL PRESENT WORTH OF COMPOSTING COSTS (5% FOR 1 YEAR)	$	1,033,000
Total Annual Post Closure Maintenance Costs	$	7,000
TOTAL PRESENT WORTH OF ANNUAL POST CLOSURE MAINTENANCE COSTS (5% FOR 30 YEARS)	$	108,000
TOTAL PRESENT WORTH OF O&M COSTS	$	1,141,000
TOTAL COST OF COMPOSTING AND CAPPING	$	5,360,000

TABLE 9-20
DETAILED ANALYSIS - ALTERNATIVE PBG-WP5
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP5 COMPOSTING AND CAPPING
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objective for protection of human health. Composting of severely contaminated soil, the RCRA caps, and institutional controls would eliminate the potential for human exposure to waste pit soil with contaminant concentrations greater than remediation goals.
Environmental Protection	No ecological risks associated with contaminated waste pit soil. Although the waste pit caps would be designed to prevent infiltration of precipitation, a large quantity of contaminants would remain close to the groundwater table in waste pit soil and would continue to present a threat to groundwater quality. VOCs could migrate out from under the caps via volatilization and lateral transport of vapors. Ensuing precipitation could then transport the VOCs to the groundwater table.
Compliance with ARARs	
Chemical-specific	Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Although excavation and treatment of severely contaminated soil would achieve pathway-specific numeric standards for protection of human health and groundwater, the unexcavated soil would not comply with pathway-specific numeric standards. The RCRA caps used in this alternative could be designed to achieve a performance standard for unexcavated SVOC-contaminated soil which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of groundwater, however, the RCRA caps could not be designed to achieve a performance standard for unexcavated VOC-contaminated soil.

continued

TABLE 9-20
DETAILED ANALYSIS - ALTERNATIVE PBG-WP5
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP5 COMPOSTING AND CAPPING
Location-specific	The following location-specific ARARs may apply to contaminants remaining on site: RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities; (40 CFR - Part 264) or WAC Chapter NR 600 RCRA, Releases from Solid Waste Management Units (Subpart F, 264.90-264.109) may apply for post-closure monitoring of the site. This alternative would include continued groundwater monitoring at the Propellant Burning Ground. Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.
Action-specific	RCRA, Land Disposal Restrictions (LDRs); (40 CFR Part 268) may apply to C6H6 waste disposed of in the waste pits. The C6H6 waste has been identified as a listed hazardous waste from non-specific sources (i.e., F005), per 40 CFR Part 261.31. As such, C6H6-contaminated soil may be subject to LDRs and, if excavated, must be treated so that it no longer "contains" C6H6 or treated to a concentration level prior to disposal in a RCRA Subtitle C permitted facility. In addition, 24DNT-contaminated soil in the waste pits would be characteristically hazardous if it exceeds the TCLP threshold for 24DNT waste. If classified as hazardous, and 24DNT-contaminated soil is excavated, the "characteristic" would have to be removed from the soil prior to disposal or placement on site. General RCRA requirements pertaining to permitted Hazardous Waste TSD units would apply to the composting facility. Federal OSHA requirements to protect worker health and safety would be followed during any site work.

TABLE 9-20
DETAILED ANALYSIS - ALTERNATIVE PBG-WP5
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP5 COMPOSTING AND CAPPING
	Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards. WDNR's Air Management Program will be contacted.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be considered prior to implementation of this alternative.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Because the severely contaminated soil would be excavated and composted, residual risk to human receptors would be negligible. Although the caps would limit natural mobilizing influences (i.e., infiltrating precipitation) on contaminants remaining in waste pit soils, the large quantity of contaminants and the inherent mobility of VOCs in the unsaturated zone would pose a long-term threat to groundwater quality.
Adequacy and Reliability of Controls	Institutional controls would protect the caps from invasive activities and restrict residential or public use of the site. Visual inspections would be conducted annually to ensure the integrity of the caps. Long-term groundwater monitoring would detect soil contaminants leaching into groundwater.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	The treatment process utilizes native microorganisms and agricultural waste amendments to biodegrade waste pit soil contaminants.
Amount Destroyed or Treated	Approximately 3,750 cubic yards of contaminated soil would be composted (approximately 1,250 cubic yards per pit). Assuming an average DNT (primary waste pit contaminant) concentration of 20,000 mg/kg, approximately 55,500 pounds of DNTs would be destroyed. The amount of VOC destruction by composting is not expected to be significant.

continued

TABLE 9-20
DETAILED ANALYSIS - ALTERNATIVE PBG-WP5
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP5 COMPOSTING AND CAPPING
Degree of Expected Reductions of Toxicity, Mobility, and Volume	Field demonstrations indicate that composting reduces the toxicity of explosives-contaminated soil, as measured by bacterial mutagenicity and aquatic toxicity, by 88 to 98 percent (R.F. Weston, Inc., 1991). The degree of VOC destruction is unknown but TRCLE destruction is expected to be less than that of explosives. Residual material is nutrient-rich compost. No other wastestreams are generated in this process. The toxicity, mobility, and volume of the remaining waste pit contaminants would not be reduced but natural mobilizing influences (i.e., infiltrating precipitation) would be limited by the caps.
Degree to Which Treatment is Irreversible	Contaminants in the excavated soil would be destroyed by composting. Remaining waste pit contaminants would not be treated.
Short-term Effectiveness	
Protection of Community During Remedial Action	The composting facility would be operating in an isolated portion of BAAP (i.e., Contaminated Waste Area) and no residences or active BAAP facilities are present within a mile of the site. The distance is expected to provide adequate dispersal of any odors and airborne contaminants.
Protection of Workers During Remedial Action	Air monitoring would be conducted at the site during excavation and composting activities. Not only is there ingestion/inhalation risk associated with VOC- and DNT-contaminated soil but there is a reactive (i.e., DNT concentrations greater than 10 percent) risk. Special precautions may be required during excavation to prevent an explosive reaction. OSHA and other health and safety requirements which limit worker exposure to inhalation hazards would be enforced. If activities resulted in unacceptable levels of air contaminants, operations would be modified to protect workers.
Environmental Impacts	The Contaminated Waste Area is not considered a critical wildlife habitat and the impact to the ecological community during soil excavation and cap construction is expected to be minor. Potential impacts to ecological receptors from composting are expected to be minimal.
Time Until Remedial Action Objectives Are Achieved	It is doubtful that the remedial action objective for protection of groundwater would be achieved. An estimated 2 months would be required for treatability testing and another 12 months would be required to achieve the remedial action objective for protection of human health.

continued

TABLE 9-20
DETAILED ANALYSIS - ALTERNATIVE PBG-WP5
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP5 COMPOSTING AND CAPPING
Implementability	
Ability to Construct and Operate the Technology	Construction of the composting facility poses no unusual design or construction problems. Operation does not require unusual skills or knowledge and is commonly practiced for agricultural wastes. Cap construction can be accomplished using standard construction procedures and conventional earth-moving equipment. Cap repairs would be easily implemented.
Reliability of the Technology	The general technical feasibility of composting explosives-contaminated soil has been successfully demonstrated at other U.S. Army sites. The feasibility of composting VOC-contaminated soil has not been demonstrated. VOC removal would likely occur via volatilization during the composting process, resulting in an uncontrolled release to the atmosphere. Site-specific treatability investigations would be necessary to confirm composting feasibility at BAAP prior to full-scale design and construction. Capping is a proven technology for reducing infiltration of precipitation and the formation of leachate in contaminated soil. Annual visual inspections and cap repair (if necessary) would ensure that the integrity of the caps is maintained.
Ease of Undertaking Additional Remedial Actions, if Necessary	The caps would increase the scope of any future soil excavation and/or treatment. The caps would have to be dismantled if soil removal or in situ soil treatment methods were implemented.
Ability to Monitor Effectiveness of Remedy	Groundwater monitoring will determine cap effectiveness for preventing groundwater contamination.
Ability to Obtain Approvals and Coordinate with Other Agencies	Administratively, composting of explosives-contaminated soil is generally supported by USEPA as a potentially viable and cost-effective technology. Composting has been identified as the selected alternative in the USEPA Record of Decision at UMDA. However, obtaining approvals from regulatory agencies for composting VOC-contaminated soil is expected to be difficult. The integrity of cap design would have to be demonstrated to federal and state regulators. Other special permits (e.g., wetland permit) would not be necessary.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Off-site Treatment, Storage, and Disposal facility and services are not required for this alternative since treatment residuals would be backfilled into the waste pits.

continued

TABLE 9-20
DETAILED ANALYSIS - ALTERNATIVE PBG-WP5
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP5 COMPOSTING AND CAPPING
Availability of Necessary Equipment and Specialists	Although composting is a well-developed technology that is used extensively throughout the country, composting explosives-contaminated soil is a new application of the process. Contractors with expertise in this application are not currently available. However, considerable contractor experience will be acquired at UMDA, which is currently undergoing remediation. Availability of equipment would not be a limitation. Obtaining sufficient clay, sand, common borrow soil, and topsoil in the vicinity of BAAP for cap construction should not be difficult.
Availability of Technology	Composting is not a complex process which requires sophisticated equipment. A large construction contracting company could provide the equipment and training to construct and operate the composting facility and to construct the caps.
Costs	
Capital Cost	$4,219,000
Present Worth of Operation and Maintenance Cost	$1,141,000
Net Present Worth Cost	$5,360,000

TABLE 9–21
COST SUMMARY TABLE
ALTERNATIVE PBG–WP7: IN–SITU VACUUM EXTRACTION, COMPOSTING, AND CAPPING

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF IN–SITU VACUUM EXTRACTION, COMPOSTING, AND CAPPING		
Treatability testing	$	90,000
Contaminated soil delineation		138,000
Site preparation and mob/demob		719,000
In–situ vacuum extraction system construction		103,000
In–situ vacuum extraction system operation		20,000
Excavate, blend, and screen contaminated soil		401,000
Backfill		209,000
Composting		1,600,000
Cap construction		138,000
TOTAL DIRECT COST OF IN–SITU VACUUM EXTRACTION, COMPOSTING, AND CAPPING	$	3,418,000
INDIRECT COST OF IN–SITU VACUUM EXTRACTION, COMPOSTING, AND CAPPING		
Health and Safety @ 5% of Total Direct Cost	$	171,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		171,000
Engineering @ 10% of Total Direct Cost		342,000
Services During Construction @ 10% of Total Direct Cost		342,000
TOTAL DIRECT COST OF IN–SITU VACUUM EXTRACTION, COMPOSTING, AND CAPPING	$	1,026,000
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$	4,444,000
OPERATING AND MAINTENANCE COSTS		
O&M of Composting System for 1 Year	$	1,085,000
TOTAL PRESENT WORTH OF COMPOSTING COSTS (5% FOR 1 YEAR)	$	1,033,000
Total Annual Operating and Maintenance Costs	$	7,000
TOTAL PRESENT WORTH OF ANNUAL POST CLOSURE MAINTENANCE COSTS (5% FOR 30 YEARS)	$	108,000
TOTAL PRESENT WORTH OF O&M COSTS	$	1,141,000
TOTAL COST OF IN–SITU VACUUM EXTRACTION, COMPOSTING, AND CAPPING	$	5,585,000

TABLE 9-22
DETAILED ANALYSIS - ALTERNATIVE PBG-WP7
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP7 IN SITU VACUUM EXTRACTION, COMPOSTING, AND CAPPING
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objective for protection of human health. In situ vacuum extraction, composting of severely contaminated soil, the RCRA caps, and institutional controls would eliminate the potential for human exposure to waste pit soil with contaminant concentrations greater than remediation goals.
Environmental Protection	No ecological risks associated with contaminated waste pit soil. The large quantity of contaminants remaining close to the groundwater table in waste pit soil may present a threat to groundwater quality. However, VOCs, which are the more mobile soil contaminants, would have been removed by in situ vacuum extraction and would no longer threaten groundwater quality. Consequently, the alternative has potential for achieving the remedial action objective for protection of groundwater.
Compliance with ARARs	
Chemical-specific	Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Excavation and treatment of severely contaminated soil would achieve the pathway-specific numeric standards for protection of human health and groundwater. Although in situ vacuum extraction used in this alternative could be designed to achieve pathway-specific numeric standards for unexcavated VOC-contaminated soil, pathway-specific numeric standards for the unexcavated SVOC-contaminated soil would not be achieved. However, the RCRA caps used in this alternative could be designed to achieve a performance standard for the unexcavated SVOC-contaminated soil which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of groundwater. Consequently, this alternative could possibly meet either the pathway-specific numeric standards derived from the proposed Chapter NR 720 or performance standards designed to meet the intent of the proposed Chapter NR 720.

TABLE 9-22
DETAILED ANALYSIS - ALTERNATIVE PBG-WP7
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP7 IN SITU VACUUM EXTRACTION, COMPOSTING, AND CAPPING
Location-specific	The following location-specific ARARs may apply to contaminants remaining on site: RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities; (40 CFR - Part 264) or WAC Chapter NR 600 RCRA, Releases from Solid Waste Management Units (Subpart F, 264.90-264.109) may apply for post-closure monitoring of the site. This alternative would include continued groundwater monitoring at the Propellant Burning Ground. Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.
Action-specific	RCRA, Land Disposal Restrictions (LDRs); (40 CFR Part 268) may apply to C6H6 waste disposed of in the waste pits. The C6H6 waste has been identified as a listed hazardous waste from non-specific sources (i.e., F005), per 40 CFR Part 261.31. As such, C6H6-contaminated soil may be subject to LDRs and, if excavated, must be treated so that it no longer "contains" C6H6 or treated to a concentration level prior to disposal in a RCRA Subtitle C permitted facility. In addition, 24DNT-contaminated soil in the waste pits would be characteristically hazardous if it exceeds the TCLP threshold for 24DNT waste. If classified as hazardous, and 24DNT-contaminated soil is excavated, the "characteristic" would have to be removed from the soil prior to disposal or placement on site. General RCRA requirements pertaining to permitted Hazardous Waste TSD units would apply to the composting facility. Federal OSHA requirements to protect worker health and safety would be followed during any site work.

continued

TABLE 9-22
DETAILED ANALYSIS - ALTERNATIVE PBG-WP7
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP7 IN SITU VACUUM EXTRACTION, COMPOSTING, AND CAPPING
	Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards. WDNR's Air Management Program will be contacted.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be considered prior to implementation of this alternative.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Because the severely contaminated soil would be excavated and composted, residual risk to human receptors would be negligible. Although the caps would limit natural mobilizing influences (i.e., infiltrating precipitation) on contaminants remaining in waste pit soils, the large quantity of SVOCs could pose a long-term threat to groundwater quality. However, SVOCs are not as mobile as VOCs in the unsaturated zone and are less of a threat to groundwater quality.
Adequacy and Reliability of Controls	Institutional controls would protect the caps from invasive activities and restrict residential or public use of the site. Visual inspections would be conducted annually to ensure the integrity of the caps. Long-term groundwater monitoring would detect soil contaminants leaching into groundwater.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	In situ vacuum extraction utilizes screened wells installed through the contaminated soil and a blower system connected to the wells to pull a vacuum on subsurface soil for VOC removal. The VOCs would be removed from the resultant vapor stream with activated carbon. The spent carbon would likely be thermally reactivated off site and the VOCs destroyed. Composting would utilize native microorganisms and agricultural waste amendments to biodegrade SVOCs in excavated soil.

continued

TABLE 9-22
DETAILED ANALYSIS - ALTERNATIVE PBG-WP7
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP7 IN SITU VACUUM EXTRACTION, COMPOSTING, AND CAPPING
Amount Destroyed or Treated	RI data indicates that a relatively small quantity of VOCs are present in waste pit soil. It is assumed that the total mass of VOCs ranges from 100 to 1,000 pounds. Approximately 3,750 cubic yards of contaminated soil would be excavated and composted (approximately 1,250 cubic yards per pit). Assuming an average DNT (primary waste pit contaminant) concentration of 20,000 mg/kg, approximately 55,500 pounds of DNTs would be destroyed. Consequently, a total of approximately 56,000 pounds of waste pit contaminants would be destroyed.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	VOC removal efficiencies of up to 99 percent are possible with in situ vacuum extraction. Off-site thermal reactivation of the spent carbon would destroy the VOCs. Field demonstrations indicate that composting reduces the toxicity of explosives-contaminated soil, as measured by bacterial mutagenicity and aquatic toxicity, by 88 to 98 percent (R.F. Weston, Inc., 1992). Residual material is nutrient-rich compost. No other wastestreams are generated in this process. The toxicity, mobility, and volume of the remaining waste pit contaminants would not be reduced but natural mobilizing influences (i.e., infiltrating precipitation) would be limited by the caps.
Degree to Which Treatment is Irreversible	VOCs in the spent carbon and SVOCs in the excavated soil would be destroyed by thermal reactivation and composting, respectively. Remaining waste pit contaminants would not be treated.
Short-term Effectiveness	
Protection of Community During Remedial Action	In situ vacuum extraction would remove VOCs that would otherwise volatilize into the atmosphere during composting. The composting facility would be operating in an isolated portion of BAAP (i.e., Contaminated Waste Area) and no residences or active BAAP facilities are present within a mile of the site. The distance is expected to provide adequate dispersal of any odors.

continued

TABLE 9-22
DETAILED ANALYSIS - ALTERNATIVE PBG-WP7
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP7 IN SITU VACUUM EXTRACTION, COMPOSTING, AND CAPPING
Protection of Workers During Remedial Action	In situ vacuum extraction would remove VOCs that would otherwise volatilize into the atmosphere during excavation and composting and potentially affect site workers. However, there is an ingestion/inhalation risk associated with DNT-contaminated soil and a reactive (i.e., DNT concentrations greater than 10 percent) risk. Special precautions may be required during excavation to prevent an explosive reaction. Air monitoring would be conducted at the site during excavation and composting activities. OSHA and other health and safety requirements which limit worker exposure to inhalation hazards would be enforced. If activities resulted in unacceptable levels of air contaminants, operations would be modified to protect workers.
Environmental Impacts	The Contaminated Waste Area is not considered a critical wildlife habitat and the impact to the ecological community during soil excavation and cap construction is expected to be minor. Potential impacts to ecological receptors from composting are expected to be minimal.
Time Until Remedial Action Objectives Are Achieved	An estimated 2 months would be required for treatability testing and another 18 months would be required to achieve the remedial action objectives. In situ vacuum extraction could be implemented concurrent with composting treatability testing, potentially shortening the overall remediation schedule.
Implementability	
Ability to Construct and Operate the Technology	Construction of the vacuum extraction system would utilize commonly-used well construction materials and vendor-supplied skid-mounted blower/treatment system assemblies. Careful monitoring of vadose zone monitoring wells would be required to operate the vacuum extraction system at maximum efficiency. Construction of the composting facility poses no unusual design or construction problems. Operation does not require unusual skills or knowledge and is commonly practiced for agricultural wastes. Cap construction can be accomplished using standard construction procedures and conventional earth-moving equipment. Cap repairs would be easily implemented.

continued

TABLE 9-22
DETAILED ANALYSIS - ALTERNATIVE PBG-WP7
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP7 IN SITU VACUUM EXTRACTION, COMPOSTING, AND CAPPING
Reliability of the Technology	In situ vacuum extraction is a well-demonstrated technology for remediation of VOC-contaminated soil. The general technical feasibility of composting explosives-contaminated soil has been successfully demonstrated at other U.S. Army sites. Site-specific treatability investigations would be necessary to confirm composting feasibility at BAAP prior to full-scale design and construction. Capping is a proven technology for reducing infiltration of precipitation and the formation of leachate in contaminated soil. Annual visual inspections and cap repair (if necessary) would ensure that the integrity of the caps is maintained.
Ease of Undertaking Additional Remedial Actions, if Necessary	The caps would increase the scope of any future soil excavation and/or treatment. The caps would have to be dismantled if soil removal or further in situ soil treatment methods were implemented.
Ability to Monitor Effectiveness of Remedy	Groundwater monitoring will determine cap effectiveness for preventing groundwater contamination.
Ability to Obtain Approvals and Coordinate with Other Agencies	In situ vacuum extraction has gained wide administrative support which is reflected in the large number of Records of Decision which include it as the preferred remedial technology at CERCLA sites. Administratively, composting of explosives-contaminated soil is generally supported by USEPA as a potentially viable and cost-effective technology. Composting has been identified as the selected alternative in the USEPA Record of Decision at UMDA. The integrity of cap design would have to be demonstrated to federal and state regulators. Other special permits (e.g., wetland permit) would not be necessary.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Off-site treatment of spent carbon would be required but the estimated quantity of spent carbon (i.e., 3,600 pounds) is not significant.

continued

Table 9-22
Detailed Analysis - Alternative PBG-WP7
Propellant Burning Ground Waste Pits

Feasibility Study
Badger Army Ammunition Plant

Evaluation Criteria	Alternative PBG-WP7 In Situ Vacuum Extraction, Composting, and Capping
Availability of Necessary Equipment and Specialists	Several contractors familiar with in situ vacuum extraction design and construction are available. Although composting is a well-developed technology that is used extensively throughout the country, composting explosives-contaminated soil is a new application of the process. Contractors with expertise in this application are not currently available. However, considerable contractor experience will be acquired at UMDA, which is currently undergoing remediation. Availability of equipment would not be a limitation. Obtaining sufficient clay, sand, common borrow soil, and topsoil in the vicinity of BAAP for cap construction should not be difficult.
Availability of Technology	A wide range of in situ vacuum extraction equipment is available from several sources. Vacuum extraction wells could be installed using material provided by local suppliers. Composting is not a complex process which requires sophisticated equipment. A large construction contracting company could provide the equipment and training to construct and operate the composting facility and to construct the caps.
Costs	
Capital Cost	$4,444,000
Present Worth of Operation and Maintenance Cost	$1,141,000
Net Present Worth Cost	$5,585,000

TABLE 9-23
COST SUMMARY TABLE
ALTERNATIVE PBG-WP8: IN-SITU TREATMENT

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST SOIL FLUSHING		TOTAL COST CHEMICAL/ BIOLOGICAL
DIRECT COST OF IN-SITU TREATMENT				
Treatability testing	$	528,000	$	528,000
Site preparation and mob/demob		347,000		347,000
Contaminated soil delineation		365,000		365,000
Barrier system construction		7,928,000		7,928,000
Infiltration basin construction		295,000		--
Water table extraction well installation		247,000		--
Confirmatory sampling		53,000		53,000
Addition of iron sulfate and hydrogen peroxide, pH adjustment, and addition of nutrients		--		(O&M)
TOTAL DIRECT COST OF IN-SITU TREATMENT	$	9,763,000	$	9,221,000
INDIRECT COST OF IN-SITU TREATMENT				
Health and Safety @ 5% of Total Direct Cost	$	488,000	$	461,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		488,000		461,000
Engineering @ 10% of Total Direct Cost		976,000		922,000
Services During Construction @ 10% of Total Direct Cost		976,000		922,000
TOTAL INDIRECT COST OF IN-SITU TREATMENT	$	2,928,000	$	2,766,000
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$	12,691,000	$	11,987,000
OPERATING AND MAINTENANCE COSTS				
Total Annual Operating and Maintenance Costs Starting 2 Years After Beginning of Project	$	349,000	$	10,754,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 11 YEARS)	$	2,629,000		
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 16 MONTHS)			$	12,287,000
TOTAL COST OF IN-SITU TREATMENT - SOIL FLUSHING	$	15,320,000		
TOTAL COST OF IN-SITU TREATMENT - CHEMICAL/BIOLOGICAL			$	24,274,000

TABLE 9-24
DETAILED ANALYSIS - ALTERNATIVE PBG-WP8
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP8 IN SITU TREATMENT
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves the remedial action objective for protection of human health. The entire volume of contaminated soil in the waste pits would be treated until remediation goals are attained. Treatment residuals from soil flushing would be destroyed off site. Chemical-biological would degrade contaminants in situ, with end products of carbon dioxide and water.
Environmental Protection	No ecological risks associated with contaminated waste pit soil. Achieves the remedial action objective for protection of groundwater. Treating the entire volume of contaminated soil to meet remediation goals would eliminate leachate generation and protect groundwater.
Compliance with ARARs	
Chemical-specific	Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Because the entire volume of contaminated soil in the waste pits would be treated to meet remediation goals, this alternative would comply with pathway-specific numeric standards derived from the proposed Chapter NR 720.
Location-specific	No location-specific ARARs.
Action-specific	Federal OSHA requirements to protect worker health and safety would be followed during any site work. Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards. WDNR's Air Management Program will be contacted. For soil flushing, discharge of treated water to the Wisconsin River would require a WPDES permit. The existing WPDES permit for the IRM facility could be modified to account for increases in contaminant concentrations in the IRM facility influent.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be considered prior to implementation of this alternative.

continued

TABLE 9-24
DETAILED ANALYSIS - ALTERNATIVE PBG-WP8
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP8 IN SITU TREATMENT
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Assuming all contaminated waste pit soil was treated to meet remediation goals, there would be no residual risk.
Adequacy and Reliability of Controls	The barrier system would be designed to contain all leachate generated during in situ treatment. Removal or destruction of all waste pit soil contaminants eliminates the need for long-term monitoring or maintenance activities.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Soil Flushing: Flushing solution (e.g., water) would be infiltrated into waste pit soil to remove soil contaminants. The flushing solution and entrained contaminants would be extracted from the bottom of the barrier system and treated with carbon adsorption and air stripping at the existing IRM facility. Chemical-Biological: Chemicals would be added and mixed into waste pit soil using deep soil mixing equipment. Chemical oxidation using iron sulfate and hydrogen peroxide would degrade waste pit soil contaminants into a readily biodegradable form. Nutrients added to the soil would stimulate the growth of indigenous populations of microorganisms to complete contaminant degradation.
Amount Destroyed or Treated	Assuming an average DNT (primary waste pit contaminant) concentration of 5,000 mg/kg, approximately 290,700 pounds (96,900 pounds per pit) of DNTs would be flushed from waste pit soil or degraded in situ. Accounting for a small quantity of VOCs in waste pit soils, a total of approximately 292,000 pounds of contaminants would be treated.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	Soil Flushing: Assuming the spent carbon from the IRM facility was either incinerated or thermally reactivated, waste pit contaminants would be destroyed. Chemical-Biological: All waste pit contaminants would ultimately be degraded into carbon dioxide and water.
Degree to Which Treatment is Irreversible	Contaminants would be destroyed by thermal treatment or chemical-biological degradation.

continued

TABLE 9-24
DETAILED ANALYSIS - ALTERNATIVE PBG-WP8
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP8 IN SITU TREATMENT
Type and Quantity of Residuals Remaining After Treatment	Soil Flushing: Assuming replacement of spent carbon in the IRM facility carbon adsorption system occurred every six weeks (20,000 lbs per episode), and approximately 186 weeks were required to achieve remediation goals in each waste pit, a total of 1,860,000 lbs (i.e., 20,000 lbs every six weeks over a period of 558 weeks) of spent carbon would be generated. If spent carbon was either incinerated or thermally reactivated, there would be no treatment residuals. Chemical-Biological: Treatment residuals from chemical-biological degradation would be environmentally benign products (i.e., carbon dioxide and water).
Short-term Effectiveness	
Protection of Community During Remedial Action	The barrier system would prevent an uncontrolled release of contaminants into surrounding subsurface soil (i.e., through lateral transport) and into the regional groundwater system. Soil Flushing: Because treatment of waste pit soil contaminants would occur in the IRM facility, with little possibility for the release of emissions, the community would not be at risk during remediation. Chemical-Biological: VOCs which may be mobilized during soil mixing, and migrate toward ground surface, would be contained by a surface foaming agent, grout layer, and/or a containment shroud on the deep soil mixing equipment. The process is not expected to produce any emissions which would present a threat to the community.

continued

TABLE 9-24
DETAILED ANALYSIS - ALTERNATIVE PBG-WP8
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP8 IN SITU TREATMENT
Protection of Workers During Remedial Action	Construction of the proposed barrier system would include invasive activities through DNT-contaminated soil. Not only is there ingestion/inhalation risk associated with VOC- and DNT-contaminated soil but there is a reactive (i.e., DNT concentrations greater than 10 percent) risk. Special precautions may be required during invasive activities to prevent an explosive reaction. Soil Flushing: Air monitoring would be conducted at the site during construction of the soil flushing systems. OSHA and other health and safety requirements which limit worker exposure to inhalation hazards would be enforced. If activities resulted in unacceptable levels of air contaminants, operations would be modified to protect workers. Chemical-Biological: Subsequent to construction of the proposed barrier system, there would be additional invasive activities through DNT-contaminated soil. As described above, there is both an ingestion/inhalation risk and a reactive risk associated with DNT-contaminated soil. Furthermore, the potential reactive risk may be enhanced by mixing hydrogen peroxide solution into DNT-contaminated soil, as would occur during the second phase of treatment. Hydrogen peroxide addition would not only supply oxygen to the subsurface but it would generate an exothermic reaction. Special precautions may be required during hydrogen peroxide addition and soil mixing to prevent an explosive reaction. Air monitoring would be conducted at the site during soil mixing. OSHA and other health and safety requirements which limit worker exposure to inhalation hazards would be enforced. If activities resulted in unacceptable levels of air contaminants, operations would be modified to protect workers.
Environmental Impacts	Because the Contaminated Waste Area is not considered a critical wildlife habitat and the area affected by remedial activities is small, the impact to the ecological community during construction is expected to be minor.

continued

TABLE 9-24
DETAILED ANALYSIS - ALTERNATIVE PBG-WP8
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP8 IN SITU TREATMENT
Time Until Remedial Action Objectives Are Achieved	An estimated 12 months is required for treatability testing and another six to 12 months is required to complete the barrier system. Soil Flushing: At a maximum in situ soil flushing rate of 250 gpm, an estimated 1,300 days are required to achieve remediation goals in each waste pit. Therefore, including treatability testing and barrier system construction, approximately 12 to 13 years would be required to achieve the remedial action objectives for all three pits. Chemical-Biological: An estimated 16 months would be required to complete the four treatment phases of chemical-biological degradation. Therefore, including treatability testing and barrier system construction, approximately 3 to 4 years would be required to achieve the remedial action objectives for all three pits.
Implementability	
Ability to Construct and Operate the Technology	Civil projects which have included excavation of watertight vertical shafts have utilized designs similar to the proposed barrier system design. Other than concerns associated with drilling through potentially reactive soil (i.e., DNT concentrations greater than 10 percent), no obstacles to barrier system construction are anticipated. Soil Flushing: Construction of the in situ soil flushing system only requires installation of an infiltration gallery and extraction well at each of the waste pits, and piping between the waste pits and existing systems (i.e., BAAP Well No.5 and the influent pipe to the IRM facility). Operation of the flushing system or IRM facility is not anticipated to pose any difficulties. Chemical-Biological: Because chemical addition is accomplished with the use of deep soil mixing equipment, no construction beyond barrier system construction is required. The proposed deep soil mixing equipment (i.e., MecTool®) has never been used at depths greater than 50 feet below ground surface. Although the contractor indicates that extending the depth capability of the equipment to 100 feet below ground surface could be easily implemented, operational concerns with the equipment remain.

continued

TABLE 9-24
DETAILED ANALYSIS - ALTERNATIVE PBG-WP8
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP8 IN SITU TREATMENT
Reliability of the Technology	Vertical slurry and grout barriers are demonstrated technologies for containing contaminated groundwater. However, the reliability of the barrier technologies in a "can" barrier system design has not been fully demonstrated. Reliability of the "can" design would have to be demonstrated during treatability tests. Soil Flushing: In situ soil flushing technology has been demonstrated at hydrocarbon-contaminated sites with a shallow groundwater table. Soil flushing has not been demonstrated for treatment of explosive-contaminated soil and has not been applied to remediation of any hazardous waste site at this scale (i.e., a 90-foot column of contaminated soil in the unsaturated zone). Although the geology is ideal for a soil flushing operation, the reliability of the technology for this application is uncertain and extensive bench- and pilot-scale treatability testing is required. Chemical-Biological: Chemical-biological treatment of PAH-contaminated soil has been demonstrated at pilot-scale. The pilot tests consisted of chemical pretreatment and co-treatment in conjunction with biological treatment of contaminated soil in a landfarming application. Chemical-biological has not been demonstrated for treatment of explosive-contaminated soil and has not been combined with deep soil mixing for treatment of subsurface soil at any hazardous waste site. Although process parameters can theoretically be controlled by the addition of chemicals to maintain optimal chemical and biological degradation environments, the reliability of the technology for this application is uncertain and extensive bench- and pilot-scale treatability testing is required.
Ease of Undertaking Additional Remedial Actions, if Necessary	Assuming all of the contaminants were flushed from waste pit soils or chemically-biologically degraded, there would be no need for additional remedial actions. If soil remediation goals were not achieved by soil flushing or chemical-biological, caps could be constructed over the waste pits to prevent infiltration of precipitation. The caps and the barrier system would ensure that mobilization of the remaining contaminants to groundwater would be prevented.
Ability to Monitor Effectiveness of Remedy	Confirmation sampling from borings installed through the thickness of the treated soil zone would determine if remediation goals have been achieved.

TABLE 9-24
DETAILED ANALYSIS - ALTERNATIVE PBG-WP8
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP8 IN SITU TREATMENT
Ability to Obtain Approvals and Coordinate with Other Agencies	Soil Flushing: Although in situ soil flushing has been selected as the preferred remedial technology for a few CERCLA sites, it is not widely accepted by regulatory agencies because its application is generally limited to sites containing permeable soils contaminated with potentially soluble compounds. A WPDES permit would be required for discharge of treated water to Lake Wisconsin. It is assumed that the carbon incineration/ reactivation facility would have the necessary permits for treatment of hazardous waste. Chemical-Biological: Although chemical-biological is an emerging technology which holds considerable promise for treating a wide variety of organic wastes, it has not been developed to the level where it can be compared to demonstrated technologies based on implementability and cost. Additional field demonstrations are required to obtain regulatory support. No special federal or state permits would be required at BAAP.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Soil Flushing: Spent carbon from the existing IRM facility is shipped to Pittsburgh, PA for reactivation. Sufficient capacity is available at that facility. If spent carbon contains DNTs over 5 percent by weight (i.e., exceeding criteria for the acceptance of spent carbon at a reactivation facility) it would then have to be shipped to an incinerator. Incinerators with sufficient capacity are available in the midwestern United States. Chemical-Biological: Other than a small quantity of treatment residuals from treatment of VOCs potentially captured during deep soil mixing, no contaminated materials would be shipped off site.

continued

TABLE 9-24
DETAILED ANALYSIS - ALTERNATIVE PBG-WP8
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP8 IN SITU TREATMENT
Availability of Necessary Equipment and Specialists	Barrier system construction equipment and expertise is available but is currently in high demand. Considerable lead time may be required for procuring services. Soil Flushing: Equipment for constructing the in situ soil flushing system (i.e., infiltration galleries, extraction wells, and piping) is available locally. Expertise for this application would have to be developed during bench- and pilot-scale testing. Chemical-Biological: Equipment and specialists for designing and implementing chemical-biological would apparently be limited to a joint venture of the Institute of Gas Technology (IGT) and Millgard Environmental Corporation (MEC). IGT would be the designer of chemical-biological treatment while MEC has the equipment to deliver the treatment chemicals to the waste pit soil. Although IGT would be able to provide testing and design services on relatively short notice, availability of deep soil mixing equipment from MEC would be dependent on their own project schedule.
Availability of Technology	Barrier system technology is available. Soil Flushing: Use of in situ soil flushing has been primarily limited to flushing petroleum hydrocarbon products from soils at sites characterized by a shallow groundwater table. Technology for flushing explosive compounds from soils with a deep groundwater table is currently not available. Chemical-Biological: Although the technology for chemical-biological is available, it has not been developed for remediation of subsurface soil. It is anticipated that only IGT and MEC could provide the technology for waste pit soil remediation.
Costs	
Capital Cost	Soil Flushing: $12,691,000 Chemical-Biological: $11,987,000
Present Worth of Operation and Maintenance Cost	Soil Flushing: $2,629,000 Chemical-Biological: $12,287,000
Net Present Worth Cost	Soil Flushing: $15,320,000 Chemical-Biological: $24,274,000

TABLE 9-25
COST SUMMARY TABLE
ALTERNATIVE PBG-WP10: ON-SITE INCINERATION

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF ON-SITE INCINERATION		
Site preparation and mob/demob	$	5,244,000
Contaminated soil delineation		365,000
Diaphragm slurry wall construction		10,500,000
Excavation of contaminated soil		(O&M)
Incineration		(O&M)
Backfill		(O&M)
TOTAL DIRECT COST OF ON-SITE INCINERATION	$	16,109,000
INDIRECT COST OF ON-SITE INCINERATION		
Health and Safety @ 5% of Total Direct Cost	$	805,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		805,000
Engineering @ 10% of Total Direct Cost		1,611,000
Services During Construction @ 10% of Total Direct Cost		1,611,000
TOTAL INDIRECT COST OF ON-SITE INCINERATION	$	4,832,000
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$	20,941,000
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs Starting 1 Year After Beginning of Project	$	21,307,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 1.5 YEARS)	$	28,641,000
TOTAL COST OF ON-SITE INCINERATION	$	49,582,000

TABLE 9-26
DETAILED ANALYSIS - ALTERNATIVE PBG-WP10
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP10 ON-SITE INCINERATION
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves the remedial action objective for protection of human health. The entire volume of contaminated soil in the waste pits would be removed and incinerated. Any residual contamination in treated soil backfilled into the excavations would meet remediation goals.
Environmental Protection	No ecological risks associated with contaminated waste pit soil. Achieves the remedial action objective for protection of groundwater. Treating the entire volume of contaminated soil to meet remediation goals would eliminate leachate generation and protect groundwater.
Compliance with ARARs	
Chemical-specific	Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Because the entire volume of contaminated soil in the waste pits would be removed and treated to meet remediation goals, this alternative would comply with pathway-specific numeric standards derived from the proposed Chapter NR 720.
Location-specific	No location-specific ARARs.
Action-specific	RCRA, Land Disposal Restrictions (LDRs); (40 CFR Part 268) may apply to C6H6 waste disposed of in the waste pits. The C6H6 waste has been identified as a listed hazardous waste from non-specific sources (i.e., F005), per 40 CFR Part 261.31. As such, C6H6-contaminated soil may be subject to LDRs and, if excavated, must be treated so that it no longer "contains" C6H6 or treated to a concentration level prior to disposal in a RCRA Subtitle C permitted facility. In addition, 24DNT-contaminated soil in the waste pits would be characteristically hazardous if it exceeds the TCLP threshold for 24DNT waste. If classified as hazardous, and 24DNT-contaminated soil is excavated, the "characteristic" would have to be removed from the soil prior to disposal or placement on site. Federal OSHA requirements to protect worker health and safety would be followed during any site work.

continued

TABLE 9-26
DETAILED ANALYSIS - ALTERNATIVE PBG-WP10
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP10 ON-SITE INCINERATION
	Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards. WDNR's Air Management Program will be contacted. It is presumed that on-site incineration would comply with all RCRA requirements for hazardous waste incinerators (40 CFR Subpart O), and all applicable Clean Air Act requirements (40 CFR 50, 52, 60, and 61). Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be considered prior to implementation of this alternative.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Assuming all contaminated waste pit soil was excavated and incinerated to meet remediation goals, there would be no residual risk.
Adequacy and Reliability of Controls	Destruction of all waste pit soil contaminants eliminates the need for long-term monitoring or maintenance activities.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	On-site incineration would destroy waste pit soil contaminants via thermal oxidation.
Amount Destroyed or Treated	Approximately 73,200 cubic yards of contaminated soil would be incinerated (approximately 24,400 cubic yards per pit). Assuming an average DNT (primary waste pit contaminant) concentration of 5,000 mg/kg, approximately 290,700 pounds of DNTs would be destroyed. Accounting for a small quantity of VOCs in waste pit soils, a total of approximately 292,000 pounds of waste pit contaminants would be destroyed.

continued

TABLE 9-26
DETAILED ANALYSIS - ALTERNATIVE PBG-WP10
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP10 ON-SITE INCINERATION
Degree of Expected Reductions of Toxicity, Mobility, and Volume	The incinerator would be permitted and operated to achieve a destruction and removal efficiency of at least 99.9999 percent.
Degree to Which Treatment is Irreversible	Contaminants in the excavated soil would be destroyed by incineration.
Type and Quantity of Residuals Remaining After Treatment	Bottom ash (i.e., treated soil), fly ash, and wastewater would be generated during incineration. Treated soil would be backfilled into the excavations. Fly ash, approximately 10 percent (i.e., 7,320 cubic yards) of the total volume treated, would transported to an off-site landfill for disposal. Wastewater would be treated on site with auxiliary equipment.
Short-term Effectiveness	
Protection of Community During Remedial Action	Although the incinerator would destroy and remove 99.9999 percent of contaminants in the feed material per the operating permit, air emissions could contain traces of contaminants. However, the incinerator would be operating in a isolated portion of BAAP (i.e., Contaminated Waste Area) and no residences or active BAAP facilities are present within a mile of the site. Modeling of emission dispersal, as is normally conducted prior to permitting incinerators, is expected to indicate that the risk to human receptors downwind of the incinerator is minor.
Protection of Workers During Remedial Action	Air monitoring would be conducted at the site during excavation and incineration activities. Not only is there ingestion/inhalation risk associated with VOC- and DNT-contaminated soil but there is a reactive (i.e., DNT concentrations greater than 10 percent) risk. Special precautions may be required during excavation to prevent an explosive reaction. OSHA and other health and safety requirements which limit worker exposure to inhalation hazards would be enforced. If site activities resulted in unacceptable levels of air contaminants, operations would be modified to protect workers.
Environmental Impacts	The Contaminated Waste Area is not considered a critical wildlife habitat and the impact to the ecological community during soil excavation and cap construction is expected to be minor. Potential impacts to ecological receptors from incinerator emissions are difficult to estimate but concentrations and the associated risk in the vicinity of the incinerator are expected to be low.

continued

TABLE 9-26
DETAILED ANALYSIS - ALTERNATIVE PBG-WP10
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP10 ON-SITE INCINERATION
Time Until Remedial Action Objectives Are Achieved	An estimated 9 to 12 months would be required for trial burns and permitting and another 12 to 16 months would be required to achieve the remedial action objectives.
Implementability	
Ability to Construct and Operate the Technology	Construction of cylindrical diaphragm walls has been previously conducted at large-scale civil projects. Transportable incinerators are available which can be mobilized to the site and operated using contractor-furnished personnel.
Reliability of the Technology	Diaphragm wall technology is a demonstrated technology in the retaining wall construction industry. Incineration is the most effective and proven method for destruction of explosive-contaminated soil (Remedial Technology Handbook Appendix A).
Ease of Undertaking Additional Remedial Actions, if Necessary	Assuming all contaminated waste pit soil was excavated and incinerated, there would be no need for additional remedial actions.
Ability to Monitor Effectiveness of Remedy	Sampling and analysis of treated soil prior to backfilling the excavations would determine the effectiveness of incineration.
Ability to Obtain Approvals and Coordinate with Other Agencies	The process for permitting an incinerator could be long and difficult. Extensive modeling of incinerator emissions may be required to show that potential receptors are not at risk. Other special permits (e.g., wetland permit) would not be necessary.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Fly ash (approximately 7,320 cubic yards) would be transported off site for disposal. An off-site landfill permitted for treatment and disposal of hazardous waste is located 108 miles from BAAP (i.e., Menomonee Falls, WI).
Availability of Necessary Equipment and Specialists	Diaphragm wall equipment and expertise is available but is currently in high demand. Considerable lead time is required for procuring diaphragm wall services. Several vendors capable of providing incineration equipment and trained personnel are available.
Availability of Technology	Diaphragm wall technology is available. Incineration equipment previously used for treatment of explosive-contaminated soil is available.

continued

TABLE 9-26
DETAILED ANALYSIS - ALTERNATIVE PBG-WP10
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP10 ON-SITE INCINERATION
Costs	
Capital Cost	$20,941,000
Present Worth of Operation and Maintenance Cost	$28,641,000
Net Present Worth Cost	$49,582,000

TABLE 9-27
COST SUMMARY TABLE
ALTERNATIVE PBG-WP11: IN-SITU VACUUM EXTRACTION, SOIL WASHING, AND COMPOSTING

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF IN-SITU VACUUM EXTRACTION, SOIL WASHING, AND COMPOSTING		
Treatability testing	$	126,000
Contaminated soil delineation		365,000
Site preparation and mob/demob		2,331,000
In-situ vacuum extraction system construction		103,000
In-situ vacuum extraction system operation		20,000
Diaphragm slurry wall construction		10,500,000
Excavation of contaminated soil		2,018,000
Soil washing		9,414,000
Composting		1,636,000
Backfill		415,000
TOTAL DIRECT COST OF IN-SITU VACUUM EXTRACTION, SOIL WASHING, AND COMPOSTING	$	26,928,000
INDIRECT COST OF IN-SITU VACUUM EXTRACTION, SOIL WASHING, AND COMPOSTING		
Health and Safety @ 5% of Total Direct Cost	$	1,346,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		1,346,000
Engineering @ 10% of Total Direct Cost		2,693,000
Services During Construction @ 10% of Total Direct Cost		2,693,000
TOTAL INDIRECT COST OF IN-SITU VACUUM EXTRACTION, SOIL WASHING, AND COMPOSTING	$	8,078,000
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$	35,006,000
OPERATING AND MAINTENANCE COSTS		
Total Composting Operating and Maintenance Costs	$	1,052,000
TOTAL PRESENT WORTH OF COMPOSTING O&M COSTS (5% FOR 3.5 YEARS)	$	3,303,000
TOTAL COST OF IN-SITU VACUUM EXTRACTION, SOIL WASHING, AND COMPOSTING	$	38,309,000

TABLE 9-28
DETAILED ANALYSIS - ALTERNATIVE PBG-WP11
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP11 IN SITU VACUUM EXTRACTION, SOIL WASHING, AND COMPOSTING
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves the remedial action objective for protection of human health. The entire volume of contaminated soil in the waste pits would be removed and treated. Any residual contamination in treated soil backfilled into the excavations would meet remediation goals.
Environmental Protection	No ecological risks associated with contaminated waste pit soil. Achieves the remedial action objective for protection of groundwater. Treating the entire volume of contaminated soil to meet remediation goals would eliminate leachate generation and protect groundwater.
Compliance with ARARs	
Chemical-specific	Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Because the entire volume of contaminated soil in the waste pits would be removed and treated to meet remediation goals, this alternative would comply with pathway-specific numeric standards derived from the proposed Chapter NR 720.
Location-specific	No location-specific ARARs.
Action-specific	RCRA, Land Disposal Restrictions (LDRs); (40 CFR Part 268) may apply to C6H6 waste disposed of in the waste pits. The C6H6 waste has been identified as a listed hazardous waste from non-specific sources (i.e., F005), per 40 CFR Part 261.31. As such, C6H6-contaminated soil may be subject to LDRs and, if excavated, must be treated so that it no longer "contains" C6H6 or treated to a concentration level prior to disposal in a RCRA Subtitle C permitted facility. In addition, 24DNT-contaminated soil in the waste pits would be characteristically hazardous if it exceeds the TCLP threshold for 24DNT waste. If classified as hazardous, and 24DNT-contaminated soil is excavated, the "characteristic" would have to be removed from the soil prior to disposal or placement on site. Federal OSHA requirements to protect worker health and safety would be followed during any site work.

continued

TABLE 9-28
DETAILED ANALYSIS - ALTERNATIVE PBG-WP11
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP11 IN SITU VACUUM EXTRACTION, SOIL WASHING, AND COMPOSTING
	Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards. WDNR's Air Management Program will be contacted. It is presumed that on-site incineration would comply with all RCRA requirements for hazardous waste incinerators (40 CFR Subpart O), and all applicable Clean Air Act requirements (40 CFR 50, 52, 60, and 61). Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be considered prior to implementation of this alternative.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Assuming all contaminated waste pit soil was excavated and treated to meet remediation goals, there would be no residual risk.
Adequacy and Reliability of Controls	Destruction of all waste pit soil contaminants eliminates the need for long-term monitoring or maintenance activities.

continued

TABLE 9-28
DETAILED ANALYSIS - ALTERNATIVE PBG-WP11
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP11 IN SITU VACUUM EXTRACTION, SOIL WASHING, AND COMPOSTING
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	In situ vacuum extraction utilizes screened wells installed through the contaminated soil and a blower system connected to the wells to pull a vacuum on subsurface soil for VOC removal. The VOCs would be removed from the resultant vapor stream with activated carbon. The spent carbon would likely be thermally reactivated off site and the VOCs destroyed. Soil washing would include separating soil fractions using mechanical screening techniques and hydrocyclones, returning clean oversized soils to the excavations, treating coarse-grained sands in air flotation tanks, returning the clean sand to the excavations, and directing the fine-grained material and the contaminated froth from the air flotation tanks to a sludge management subsystem where it is eventually dewatered to produce a 50-60 percent solids filter cake. The filter cake from soil washing would be treated by composting. Composting would utilize native microorganisms and agricultural waste amendments to biodegrade contaminants in the filter cake.
Amount Destroyed or Treated	Approximately 73,200 cubic yards of contaminated soil would be treated (approximately 24,400 cubic yards per pit). Assuming an average DNT (primary waste pit contaminant) concentration of 5,000 mg/kg, approximately 290,700 pounds of DNTs would be destroyed. Accounting for a small quantity of VOCs in waste pit soils, a total of approximately 292,000 pounds of waste pit contaminants would be destroyed.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	VOC removal efficiencies of up to 99 percent are possible with in situ vacuum extraction. Off-site thermal reactivation of the spent carbon would destroy the VOCs. Soil washing is capable of volume reductions of approximately 90 percent. All coarse-grained sands and larger soil fractions would be returned to the excavations after soil washing. Field demonstrations indicate that composting reduces the toxicity of explosives-contaminated soil, as measured by bacterial mutagenicity and aquatic toxicity, by 88 to 98 percent (R.F. Weston, Inc., 1991). Residual material is nutrient-rich compost. No other wastestreams are generated in this process.
Degree to Which Treatment is Irreversible	VOCs in the spent carbon and SVOCs in the excavated soil would be destroyed by thermal reactivation and composting, respectively.

continued

TABLE 9-28
DETAILED ANALYSIS - ALTERNATIVE PBG-WP11
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP11 IN SITU VACUUM EXTRACTION, SOIL WASHING, AND COMPOSTING
Short-term Effectiveness	
Protection of Community During Remedial Action	In situ vacuum extraction would remove VOCs that would otherwise volatilize into the atmosphere during excavation and soil washing. The soil washing and composting facilities would be operating in an isolated portion of BAAP (i.e., Contaminated Waste Area) and no residences or active BAAP facilities are present within a mile of the site. The distance is expected to provide adequate dispersal of any odors from composting.
Protection of Workers During Remedial Action	In situ vacuum extraction would remove VOCs that would otherwise volatilize into the atmosphere during excavation and soil washing, and potentially affect site workers. However, there is an ingestion/inhalation risk associated with DNT-contaminated soil and a reactive (i.e., DNT concentrations greater than 10 percent) risk. Special precautions may be required during excavation to prevent an explosive reaction. Air monitoring would be conducted at the site during excavation and composting activities. OSHA and other health and safety requirements which limit worker exposure to inhalation hazards would be enforced. If activities resulted in unacceptable levels of air contaminants, operations would be modified to protect workers.
Environmental Impacts	The Contaminated Waste Area is not considered a critical wildlife habitat and the impact to the ecological community during soil excavation is expected to be minor. Potential impacts to ecological receptors from soil washing and composting are expected to be minimal.
Time Until Remedial Action Objectives Are Achieved	An estimated 6 months would be required for treatability testing and another 3 years would be required to achieve the remedial action objectives. This estimate assumes in situ vacuum extraction would be implemented concurrent with soil washing and compositing treatability testing.

continued

TABLE 9-28
DETAILED ANALYSIS - ALTERNATIVE PBG-WP11
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP11 IN SITU VACUUM EXTRACTION, SOIL WASHING, AND COMPOSTING
Implementability	
Ability to Construct and Operate the Technology	Construction of the vacuum extraction system would utilize commonly-used well construction materials and vendor-supplied skid-mounted blower/treatment system assemblies. Careful monitoring of vadose zone monitoring wells would be required to operate the vacuum extraction system at maximum efficiency. Soil washing treatment plants are typically composed of system modules installed on engineered skids. The modules are equipped with quick disconnects and flexible hosing for easy assembly/disassembly. The plant would be operated using contractor-furnished personnel. Construction of the composting facility poses no unusual design or construction problems. Operation does not require unusual skills or knowledge and is commonly practiced for agricultural wastes.
Reliability of the Technology	In situ vacuum extraction is a well-demonstrated technology for remediation of VOC-contaminated soil. Soil washing is also a well-demonstrated technology but its operational experience is primarily limited to soil and sludge remediation in Europe. Consequently, it is considered an innovative technology in the U.S. However, soil washing was recently used to successfully remediate a Superfund site in New Jersey, where sandy soils had been contaminated with metals. The general technical feasibility of composting explosives-contaminated soil has been successfully demonstrated at other U.S. Army sites. Site-specific treatability investigations would be necessary to confirm soil washing and composting feasibility at BAAP prior to full-scale design and construction.
Ease of Undertaking Additional Remedial Actions, if Necessary	Assuming all contaminated waste pit soil was excavated and treated, there would be no need for additional remedial actions.
Ability to Monitor Effectiveness of Remedy	Sampling and analysis of treated soil prior to backfilling the excavations would determine the effectiveness of soil washing and composting.

continued

TABLE 9-28
DETAILED ANALYSIS - ALTERNATIVE PBG-WP11
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP11 IN SITU VACUUM EXTRACTION, SOIL WASHING, AND COMPOSTING
Ability to Obtain Approvals and Coordinate with Other Agencies	In situ vacuum extraction has gained wide administrative support which is reflected in the large number of Records of Decision which include it as the preferred remedial technology at CERCLA sites. Although soil washing is relatively new in the U.S., USEPA's preference for proven innovative remedial technologies over controversial conventional technologies (e.g., incineration) would ensure easy approval. Administratively, composting of explosives-contaminated soil is generally supported by USEPA as a potentially viable and cost-effective technology. Composting has been identified as the selected alternative in the USEPA Record of Decision at UMDA. Other special permits (e.g., wetland permit) would not be necessary.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Off-site treatment of spent carbon from in situ vacuum extraction would be required but the estimated quantity of spent carbon (i.e., 3,600 pounds) is relatively insignificant. An unknown quantity of wastewater treatment residuals from soil washing would also require off-site treatment. However, the wastewater flows would not be substantial and the resulting quantity of treatment residuals should also be insignificant.
Availability of Necessary Equipment and Specialists	Several contractors familiar with in situ vacuum extraction design and construction are available. Only a few soil washing contractors are currently available in the U.S., however, based on the demonstrated success of soil washing, the number of soil washing contractors should increase considerably in the next few years. Although composting is a well-developed technology that is used extensively throughout the country, composting explosives-contaminated soil is a new application of the process. Contractors with expertise in this application are not currently available. However, considerable contractor experience will be acquired at UMDA, which is currently undergoing remediation. Availability of equipment would not be a limitation for any of the technologies.

continued

TABLE 9-28
DETAILED ANALYSIS - ALTERNATIVE PBG-WP11
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-WP11 IN SITU VACUUM EXTRACTION, SOIL WASHING, AND COMPOSTING
Availability of Technology	A wide range of in situ vacuum extraction equipment is available from several sources. Vacuum extraction wells could be installed using equipment and material provided by local contractors. Soil washing is not a technology which requires highly specialized equipment. Most of the components consist of modified wastewater treatment equipment. Composting is also not a complex process which requires sophisticated equipment. A large construction contracting company could provide the equipment and training to construct and operate the composting facility.
Costs	
Capital Cost	$35,006,000
Present Worth of Operation and Maintenance Cost	$3,303,000
Net Present Worth Cost	$38,309,000

TABLE 9-29
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative PBG-WP1: Minimal Action	Reduces potential for human exposure to contaminated soil. Not protective of groundwater.	No chemical-specific ARARs. This alternative would not meet the intent of the proposed Chapter NR 720 standards for protection of human health and groundwater.	If managed properly, residual risk to human receptors wold be minor. No reduction in the threat of groundwater contamination.	Contamination is not treated or destroyed; no reduction of toxicity, mobility, or volume of contaminants.	No adverse community or environmental impacts during implementation.	No implementability concerns.	Total Present Worth: $118,000 Capital Cost: $10,000 Annual O&M: $7,000 (30 yrs)
Alternative PBG-WP4: On-Site Incineration and Capping	Achieves remedial action objectives for protection of human health. Large quantity of contaminants would remain in waste pit soils. Caps would not provide total containment needed to protect groundwater.	No chemical-specific ARARs. This alternative could meet the intent of the proposed Chapter NR 720 standards for protection of human health but not groundwater.	Residual risk to human receptors would be negligible but the large quantity of contaminants and the inherent mobility of VOCs would pose a significant long-term threat to groundwater quality.	Incinerator destruction and removal efficiency would be at least 99.9999 percent. Caps would limit natural mobilizing influences on remaining contaminants.	Because the incinerator would be operating in a isolated location, risks associated with emissions are expected to be minor. Reactive risk associated with excavating/handling DNT-contaminated soil.	No implementability concerns. Incineration is a proven technology for explosive-contaminated soil. Caps are easily constructed and maintained.	Total Present Worth: $6,793,000 Capital Cost: $6,685,000 Closure O&M: $7,000/yr (30 yrs)
Alternative PBG-WP5: Composting and Capping	Achieves remedial action objective for protection of human health. Large quantity of contaminants would remain in waste pit soils. Caps would not provide total containment needed to protect groundwater.	No chemical-specific ARARs. This alternative could meet the intent of the proposed Chapter NR 720 standards for protection of human health but not groundwater.	Residual risk to human receptors would be negligible but the large quantity of contaminants and the inherent mobility of VOCs would pose a significant long-term threat to groundwater quality.	Bacterial mutagenicity and aquatic toxicity reduced by 88 to 98 percent. Caps would limit natural mobilizing influences on remaining contaminants.	Remote location of composting site would provide for adequate dispersal of odors and airborne contaminants. Reactive risk associated with excavating/handling DNT-contaminated soil.	Minor implementability concerns. While general technical feasibility of composting has been demonstrated at similar sites, treatability studies would be required prior to full-scale design and construction.	Total Present Worth: $5,360,000 Capital Cost: $4,219,000 Composting O&M: $1,085,000 1 yr Closure O&M: $7,000/yr (30 yrs)

continued

TABLE 9-29
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative PBG-WP7: In Situ Vacuum Extraction, Composting, and Capping	Achieves remedial action objective for protection of human health. Although a large quantity of contaminants would remain in waste pit soils, in situ vacuum extraction would have removed the more mobile VOCs. Caps may provide total containment of remaining SVOCs and protect groundwater.	No chemical-specific ARARs. This alternative could possibly meet either numeric standards or performance standards for protection of human health and groundwater per the proposed Chapter NR 720 standards.	Residual risk to human receptors would be negligible. Large quantities of contaminants would pose a significant long-term threat to groundwater quality. However, removal of VOCs could result in reduced threat to groundwater quality.	VOC removal efficiencies of up to 99 percent are possible with in situ vacuum extraction. Composting reduces bacterial mutagenicity and aquatic toxicity by 88 to 98 percent.	Remote location of composting site would provide for adequate dispersal of odors. Reactive risk associated with excavating/handling DNT-contaminated soil.	Minor implementability concerns. While general technical feasibility of in situ vacuum extraction and composting has been demonstrated, treatability studies would be required prior to full-scale design and construction.	Total Present Worth: <u>$5,585,000</u> Capital Cost: $4,444,000 Composting O&M: $1,085,000/ 1 yr Closure O&M: $7,000/yr (30 yrs)
Alternative PBG-WP8: In Situ Treatment	Achieves remedial action objectives for protection of human health and groundwater.	No chemical-specific ARARs. This alternative would comply with pathway-specific numeric standards derived from the proposed Chapter NR 720.	No residual risk.	<u>Soil Flushing</u> Existing IRM facility would achieve removal efficiency greater than 99 percent. Off-site destruction of contaminants in spent carbon. <u>Chemical-Biological</u> Chemical oxidation and biodegradation would result in complete contaminant degradation.	<u>Soil Flushing</u> Because there would be no excavation of contaminated soil and treatment would occur in the IRM facility, overall risk would be minimal. <u>Chemical-Biological</u> VOCs would be contained during soil mixing. Reactive risk associated with mixing DNT-contaminated soil may be exacerbated by addition of hydrogen peroxide.	Potentially significant implementability concerns. In situ soil flushing and chemical-biological have not been applied to explosive-contaminated soil or to remediation of any site at this scale. Extensive treatability testing is required.	Soil Flushing Total Present Worth: <u>$15,320,000</u> Capital Cost: $12,691,000 O&M: $349,000/yr (11 yrs) Chemical-Biological Total Present Worth: <u>$24,274,000</u> Capital Cost: $11,987,000 O&M: $10,754,000/ yr (16 months)

continued

TABLE 9-29
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
PROPELLANT BURNING GROUND WASTE PITS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative PBG-WP10: On-Site Incineration	Achieves remedial action objectives for protection of human health and groundwater.	No chemical-specific ARARs for soil. However, destroying soil contaminants would eliminate generation of leachate. This alternative would comply with pathway-specific numeric standards derived from the proposed Chapter NR 720.	No residual risk.	Incinerator destruction and removal efficiency would be at least 99.9999 percent.	Because the incinerator would be operating in an isolated location, risks associated with emissions are expected to be minor. Reactive risk associated with excavating/handling DNT-contaminated soil.	No implementability concerns. Diaphragm wall technology has been demonstrated in large-scale civil projects. Incine-ration is a proven technology for explosive-con-taminated soil.	Total Present Worth: $49,582,000 Capital Cost: $20,941,000 Annual O&M: $21,307,000 (1.5 yrs)
Alternative PBG-WP11: In Situ Vacuum Extraction, Soil Washing, and Composting	Achieves remedial action objectives for protection of human health and groundwater.	No chemical-specific ARARs. This alternative would comply with pathway-specific numeric standards derived from the proposed Chapter NR 720.	No residual risk	VOC removal efficiencies of up to 99 percent are possible with in situ vacuum extraction. Soil washing is capable of volume reductions of approximately 90 percent. Composting reduces bacterial mutagenicity and aquatic toxicity by 88 to 98 percent.	Remote location of composting site would provide for adequate dispersal of odors. Reactive risk associated with excavating/ handling DNT-contaminated soil.	Minor implement-ability concerns. While general technical feasibility of insitu vacuum extraction, soil washing, and com-posting has been demonstrated. Treatability studies would be required prior to full-scale design and construction.	Total Present Worth: $38,309,000 Capital Cost: $35,006,000 Annual O&M: $1,052,000 (3.5 yrs)

Notes:

ARARs = Applicable or Relevant and Appropriate Requirements
IRM = Interim Remedial Measures
VOCs = volatile organic compounds

TABLE 9-30
GROUNDWATER MONITORING PROGRAM
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GROUNDWATER MONITORING LOCATIONS (58)		
PBN 8201 A, B, C	PBN 8202 A, B, C	LON 8903 A,B
PBN 8203 A, B, C	PBN 8204 A, B, C	PBN 9112 C,D
PBN 8205 A, B, C	PBM 8506	BGM 9102
PBN 8501 A	PBN 8502 A	LOM 9102
PBN 8503 A	PBN 8504 A	PBN 8903 B
PBM 8906	PBN 8901 B, C, D	PBN 9106 C, D
PBN 8902 B, C	PBN 8903 C	BGM 9101
PBN 8904 B, C	PBN 8910 A, B, C, D	BGM 9103
PBN 8912 A, B	LON 8902 A, B	PBM 8204

Note:

Not included in this list are the nine monitoring wells recently installed by the U.S. Army Corps of Engineers along the eastern edge of the groundwater contaminant plume. These nine wells, as yet unnumbered, are included in the groundwater monitoring program.

ANALYTICAL PARAMETERS AND MONITORING FREQUENCY	
QUARTERLY	ANNUALLY
pH	VOCs, SVOCs, and Metals (filtered)[1]
Specific Conductance	
Nitrate Nitrogen	
Carbon Tetrachloride	
Chloroform	
Trichloroethylene	
1,1,1-Trichloroethylene	

Notes:

[1] VOCs, SVOCs, and metals as described in Modification of Conditional Plan Approval of In-Field Conditions Report (WDNR, 1992).

TABLE 9-31
COST SUMMARY TABLE
ALTERNATIVE PBG-GW1: MINIMAL ACTION

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF MINIMAL ACTION		
Institutional controls	$	10,000
TOTAL DIRECT COST OF MINIMAL ACTION	**$**	**10,000**
INDIRECT COST OF MINIMAL ACTION		
Health and Safety @ 0% of Total Direct Cost	$	0
Legal, Administration, Permitting @ 0% of Total Direct Cost		0
Engineering @ 0% of Total Direct Cost		0
Services During Construction @ 0% of Total Direct Cost		0
TOTAL INDIRECT COST OF MINIMAL ACTION	**$**	**0**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**10,000**
OPERATING AND MAINTENANCE COSTS		
Total cost replacement wells	$	22,000
Total present worth of replacement wells in year 16, 32, 48 @ 5%	$	17,000
Total Annual Operating and Maintenance Costs	$	387,000
Total present worth of annual O&M costs (5% for 65 years)	$	7,415,000
TOTAL PRESENT WORTH OF O&M COSTS	**$**	**7,432,000**
TOTAL COST FOR GW-1 MINIMAL ACTION	**$**	**7,442,000**

TABLE 9-32
DETAILED ANALYSIS - ALTERNATIVE PBG-GW1
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW1 - MINIMAL ACTION
Overall Protection of Human Health and the Environment	
Human Health Protection	Under a minimal action scenario, the public would continue to be potentially exposed to contaminated drinking water. Even with the benefit of the existing IRM treatment system, chemical concentrations within the contaminant plume would likely increase, and the plume's areal extent could expand.
Environmental Protection	Ecological receptors are not at risk because there are no direct routes of exposure to aquatic or terrestrial biota; therefore, the alternative is protective of the environment.
Compliance with ARARs	
Chemical-specific	Would not meet chemical-specific ARARs for groundwater beneath the source area until the source area is removed or treated in place. Until that time the groundwater below it will continue to be contaminated and not meet chemical-specific ARARs. Concentrations of contaminants in groundwater downgradient of the source area may be attenuated by chemical and/or biological degradation, but attainment of chemical-specific ARARs is not certain.
Location-specific	Location-specific ARARs pertaining to wetlands and surface water do not apply to this alternative.
Action-specific	Action-specific ARARs do not apply to this alternative because no action would be taken.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Currently, groundwater in the area does not meet remediation goals. The residual risk may eventually decrease to an acceptable level by chemical and/or biological degradation but not before chemical concentrations within the contaminant plume increase or before the plume migrates further downgradient.
Adequacy and Reliability of Controls	Not Applicable. No controls would be used in this alternative.

continued

TABLE 9-32
DETAILED ANALYSIS - ALTERNATIVE PBG-GW1
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW1 - MINIMAL ACTION
Reduction of Toxicity, Mobility, or Volume through Treatment	
Treatment Process Used and Materials Treated	Not Applicable. No treatment is used in this alternative.
Amount Destroyed or Treated	No contamination is destroyed or treated.
Degree of Expected Reductions of Toxicity, Mobility, or Volume through Treatment	No reduction of toxicity, mobility, or volume through treatment because treatment is not used.
Degree to Which Treatment is Irreversible	No treatment is used.
Type and Quantity of Residuals Remaining After Treatment	No treatment is used.
Short-term Effectiveness	
Protection of Community during Remedial Action	No adverse or beneficial impact to the community would occur because no remedial actions would be implemented.
Worker Protection during Remedial Action	No adverse worker impacts because no remedial actions would be implemented.
Environmental Impacts	No direct or indirect short-term adverse ecological effects would occur because no remedial actions would be implemented.
Time until Remedial Action Objectives are Achieved	Unknown. Remedial action would not occur; however, the aquifer could cleanse itself over many years.

continued

TABLE 9-32
DETAILED ANALYSIS - ALTERNATIVE PBG-GW1
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW1 - MINIMAL ACTION
Implementability	
Ability to Construct and Operate the Technology	No construction would occur.
Reliability of Technology	No technologies would be used.
Ease of Undertaking Additional Remedial Action, if Necessary	No action would not limit or interfere with the ability to perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Monitoring program can be implemented using existing monitoring wells.
Ability to Obtain Approvals and Coordinate with other Agencies	No permits would be required.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Not required.
Availability of Necessary Equipment and Specialists	No equipment would be required.
Availability of Technology	No technologies would be used.
Cost	
Capital Cost	$10,000
Present Worth of Operation and Maintenance Cost	$7,432,000
Net Present Worth Cost	$7,442,000

Notes:

ARARs = Applicable or Relevant and Appropriate Requirements
RG = Remediation Goal

TABLE 9-33
TREATMENT FACILITY INFLUENT CONCENTRATIONS AND SURFACE WATER DISCHARGE LIMITS PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY REPORT BADGER ARMY AMMUNITION PLANT

COMPOUND	MAXIMUM CONCENTRATION DETECTED[1] (μg/ℓ)	ASSUMED CONCENTRATIONS IN INFLUENT FROM PROPOSED BOUNDARY CONTROL WELLS[2] (μg/ℓ)	ASSUMED CONCENTRATIONS IN INFLUENT FROM PROPOSED SOURCE CONTROL WELLS[3] (μg/ℓ)	ESTIMATED SURFACE WATER DISCHARGE LIMIT[4] (μg/ℓ)
CCL4	108	19.2	2.0	<1
CHCL3	83.5	4.82	3.0	<1
TRCLE	117	19.4	18.0	<1
26DNT	1.46	2.53	9.6	<0.05
NNDPA	25	NA	NA	<1
BE	0.582	NA	NA	--
HG	4.31	NA	NA	--
MN	1,700	NA	NA	--
SO4	637,000	NA	NA	--
C6H6[5]	ND	<1	<1	<0.2
111TCE[5]	59.3	1.48	1.0	<1
24DNT[5]	ND	3.81	11.5	<0.05
1,2DCLE[5]	ND	1.0	<1	<1

Notes:

1 Maximum concentration detected in monitoring wells.
2 Actual average concentrations in existing IRM facility influent, November 1992 (Olin, 1992).
3 Actual concentrations in existing IRM facility source control well, November 1992 (Olin, 1992).
4 Estimated discharge limits assume 99% removal of organic contaminants is required.
5 Compound was not identified in the RI Report (ABB-ES, 1993) as representing an unacceptable risk but has been detected or is suspected to be in the existing IRM facility influent.

NA = Not analyzed
ND = Not detected
-- = No estimated discharge limit for inorganic compounds

TABLE 9-34
ESTIMATED AQUIFER CLEANUP TIMES
FOR MAJOR ORGANIC CONTAMINANTS
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY REPORT
BADGER ARMY AMMUNITION PLANT

		Cleanup Time (Years)	
Compound	Preliminary Remediation Goal (μg/ℓ)	foc = 0.001	foc = 0.0001
CCL4	5	72	23.4
CHCL3	6	41.4	18
TRCLE	5	77.4	23.4
24DNT	0.05	55.8	23.4
26DNT	0.05	86.4	28.8

Notes:

μg/ℓ = Micrograms per liter
foc = Organic carbon fraction in the aquifer

TABLE 9-35
GROUNDWATER TREATMENT SYSTEM
SAMPLING AND ANALYSIS PROGRAM

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	USEPA METHOD
C6H6	624
CCL4	624
CHCL3	624
1,2DCLE	624
111TCE	624
TRCLE	624
24DNT	625
26DNT	625
NNDPA	625
BE	200.7
HG	245.1
MN	200.7
SO4	375.4

TABLE 9-36
COST SUMMARY TABLE
ALTERNATIVE PBG-GW2: IRM AND CARBON ADSORPTION

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF IRM AND CARBON ADSORPTION		
Site preparation and mob/demob	$	402,000
Extraction system construction		2,855,000
Carbon adsorption treatment facility construction		579,000
Process equipment		1,177,000
Effluent pipe modification		12,000
IRM facility modification		28,000
TOTAL DIRECT COST OF IRM AND CARBON ADSORPTION	**$**	**5,053,000**
INDIRECT COST OF IRM AND CARBON ADSORPTION		
Health and Safety @ 5% of Total Direct Cost	$	253,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		253,000
Engineering @ 10% of Total Direct Cost		505,000
Services During Construction @ 10% of Total Direct Cost		505,000
TOTAL INDIRECT COST OF IRM AND CARBON ADSORPTION	**$**	**1,516,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**6,569,000**
OPERATING AND MAINTENANCE COSTS		
Total cost replacement wells	$	22,000
Total present worth of replacement wells in year 16, 32, 48 @ 5%	$	17,000
Total Annual Operating and Maintenance Costs	$	1,485,000
Total present worth of annual O&M costs (5% for 65 years)	$	28,454,000
TOTAL PRESENT WORTH OF O&M COSTS	**$**	**28,471,000**
TOTAL COST FOR IRM AND CARBON ADSORPTION	**$**	**35,040,000**

TABLE 9-37
DETAILED ANALYSIS - ALTERNATIVE PBG-GW2
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW2 IRM AND CARBON ADSORPTION
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objectives for human receptors downgradient of the source area (i.e., Contaminated Waste Area). This alternative would both prevent migration of contaminated groundwater off BAAP and reduce contaminant concentrations in groundwater downgradient of the source area to acceptable levels. Remedial action objectives for groundwater beneath the source area would not be achieved until the source is removed or treated in situ.
Environmental Protection	No ecological risks associated with contaminated groundwater.
Compliance with ARARs	
Chemical-specific	The WPAL (WAC Chapter NR 140.10, Table 1) for CCL4, CHCL3, TRCLE, 111TCE, 24DNT, 26DNT, CR, PB, CD, and HG would be achieved in the aquifer downgradient of the source control wells. The interim WPAL for BE and NNDPA would be achieved in the aquifer downgradient of the source control wells. Secondary drinking water standards for MN and SO4 would be achieved in the aquifer downgradient of the source control wells. This alternative would not meet chemical-specific ARARs for groundwater beneath the source area until the source is removed or treated in situ. A WPDES (WAC Chapter NR 205) permit issued for discharge of treated groundwater to the Wisconsin River will specify individual discharge limits for each of the groundwater contaminants. It is presumed that this alternative is capable of achieving those limits.
Location-specific	No location-specific ARARs.
Action-specific	Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be implemented prior to implementing this alternative.

continued

TABLE 9-37
DETAILED ANALYSIS - ALTERNATIVE PBG-GW2
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW2 IRM AND CARBON ADSORPTION
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	This alternative would be implemented to comply with WPALs and secondary drinking water standards. The standards were developed to minimize risk; therefore, the magnitude of the residual risk would be minimal. However, groundwater treatment is not a permanent solution because it would continue indefinitely unless the source is removed. Therefore, there may be an inherent residual risk unless the source is remediated.
Adequacy and Reliability of Controls	After remedial action objectives have been achieved downgradient of the source control wells, continued operation of the source control wells (assuming the source has not been removed) and groundwater monitoring would ensure the aquifer is not recontaminated. If the source has been removed, long-term monitoring after achieving remedial action objectives for groundwater would not be required.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Carbon adsorption in the new treatment facility (i.e., carbon adsorption treatment facility) would be used to remove CCL4, CHCL3, TRCLE, 111TCE, 24DNT, 26DNT, and NNDPA from groundwater. Aqueous-phase carbon followed by air stripper polish would be used in the IRM facility. Thermal reactivation of spent carbon would destroy adsorbed contaminants. Treatment of BE, CR, PB, CD, HG, MN, and SO4 is not expected to be necessary in order to meet surface water discharge limits.
Amount Destroyed or Treated	During the first year of operation, approximately 430 lbs of organic contaminants would be adsorbed in the carbon adsorption systems at the new facility and the IRM facility and destroyed during thermal reactivation. The mass of contaminants adsorbed and destroyed annually would decrease with each ensuing year because of decreasing contaminant concentrations that result from aquifer flushing.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	The WPDES permit issued for discharge of treated groundwater is expected to require a treatment system removal efficiency of at least 99 percent. Groundwater contaminants adsorbed to the spent carbon would be destroyed during thermal reactivation.

continued

TABLE 9-37
DETAILED ANALYSIS - ALTERNATIVE PBG-GW2
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW2 IRM AND CARBON ADSORPTION
Degree to Which Treatment is Irreversible	Groundwater contaminants would be destroyed during thermal reactivation of the spent carbon.
Type and Quantity of Residuals Remaining After Treatment	Approximately 240,000 lbs of spent carbon in the new facility and approximately 120,000 lbs of spent carbon in the IRM facility would be generated every year (Rogers, 1993). Therefore, a total of approximately 360,000 lbs of spent carbon would be generated annually. Assuming complete destruction of contaminants in the spent carbon during thermal reactivation, no residuals would remain.
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation. There are no residences close enough to the site to be affected by noise or dust generated during construction of the new treatment facility.
Protection of Workers During Remedial Action	With the use of dust suppression techniques and adherence to general health and safety practices during construction, there would be minimal risk to workers.
Environmental Impacts	Adverse impacts to the environment may occur during construction of extraction wells and influent pipelines, particularly in the vicinity of the boundary control wells. Construction in the vicinity of the boundary control wells may require clearing trees which may adversely impact wildlife habitat.
Time Until Remedial Action Objectives Are Achieved	An estimated 41 to 86 years is required to achieve all the remedial action objectives for groundwater downgradient of the source area. Time required for cleanup of groundwater beneath the source area is dependent on remediation of the source area itself.
Implementability	
Ability to Construct and Operate the Technology	Construction of the new facility (i.e., carbon adsorption treatment facility) and modification of the IRM facility would not be difficult. Carbon adsorption system operating practices would include replacing carbon at breakthrough <u>or</u> before DNT loading on the carbon exceeds five percent DNTs by weight. The DNT loading limit is enforced by the thermal reactivation facility. However, operation of the existing IRM facility has shown that breakthrough occurs well before the DNT loading limit is exceeded.

continued

TABLE 9-37
DETAILED ANALYSIS - ALTERNATIVE PBG-GW2
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW2 IRM AND CARBON ADSORPTION
Reliability of the Technology	Carbon adsorption is a proven technology for removing organic contaminants from groundwater. The existing IRM facility (and associated carbon adsorption system) has been successfully operated for more than three years treating Propellant Burning Ground groundwater. Monitoring for contaminant breakthrough between the carbon vessels would ensure that WPDES discharge limits are not exceeded.
Ease of Undertaking Additional Remedial Action, if Necessary	This alternative would not preclude or hinder activities conducted during soil remediation at the Contaminated Waste Area.
Ability to Monitor Effectiveness of Remedy	The effectiveness of the treatment system would be monitored by analysis of samples collected bi-weekly from treatment systems influent and effluent. Aquifer cleanup can be monitored via the groundwater monitoring program.
Ability to Obtain Approvals and Coordinate with Other Agencies	Obtaining a WPDES permit for the discharge of treated groundwater to the Wisconsin River is not expected to be difficult. The existing IRM facility currently operates under a WPDES permit. Other special permits (e.g., wetland permit) would not be necessary.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Facilities which have sufficient capacity for the reactivation of spent carbon are available.
Availability of Necessary Equipment and Specialists	Carbon adsorption equipment and expertise is available from several vendors.
Availability of Technology	Carbon adsorption technology for the treatment of groundwater contaminated with chlorinated compounds and explosives is available.
Costs	
Capital Cost	$6,569,000
Present Worth of Operation and Maintenance Cost	$28,471,000
Net Present Worth Cost	$35,040,000

TABLE 9–38
COST SUMMARY TABLE
ALTERNATIVE PBG–GW4: IRM AND AIR STRIPPING–CARBON ADSORPTION

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM	TOTAL COST
DIRECT COST OF IRM AND AIR STRIPPING–CARBON ADSORPTION	
Site preparation and mob/demob	$ 402,000
Extraction system construction	2,855,000
Air stripping–carbon adsorption treatment facility construction	749,000
Process equipment	1,571,000
Effluent pipe modification	12,000
IRM facility modification	28,000
TOTAL DIRECT COST OF IRM AND AIR STRIPPING–CARBON ADSORPTION	**$ 5,617,000**
INDIRECT COST OF IRM AND AIR STRIPPING–CARBON ADSORPTION	
Health and Safety @ 5% of Total Direct Cost	$ 281,000
Legal, Administration, Permitting @ 5% of Total Direct Cost	281,000
Engineering @ 10% of Total Direct Cost	562,000
Services During Construction @ 10% of Total Direct Cost	562,000
TOTAL INDIRECT COST OF IRM AND AIR STRIPPING–CARBON ADSORPTION	**$ 1,686,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$ 7,303,000**
OPERATING AND MAINTENANCE COSTS	
Total cost replacement wells	$ 22,000
Total present worth of replacement wells in year 16, 32, 48 @ 5%	$ 17,000
Total Annual Operating and Maintenance Costs	$ 1,474,000
Total present worth of annual O&M costs (5% for 65 years)	$ 28,243,000
TOTAL PRESENT WORTH OF O&M COSTS	**$ 28,260,000**
TOTAL COST FOR IRM AND AIR STRIPPING–CARBON ADSORPTION	**$ 35,563,000**

TABLE 9-39
DETAILED ANALYSIS - ALTERNATIVE PBG-GW4
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW4 IRM AND AIR STRIPPING - CARBON ADSORPTION
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objectives for human receptors downgradient of the source area (i.e., Contaminated Waste Area). This alternative would both prevent migration of contaminated groundwater off BAAP and reduce contaminant concentrations in groundwater downgradient of the source area to acceptable levels. Remedial action objectives for groundwater beneath the source area would not be achieved until the source is removed or treated in situ.
Environmental Protection	No ecological risks associated with contaminated groundwater.
Compliance with ARARs	
Chemical-specific	The WPAL (WAC Chapter NR 140.10, Table 1) for CCL4, CHCL3, TRCLE, 111TCE, 24DNT, 26DNT, CR, PB, CD, and HG would be achieved in the aquifer downgradient of the source control wells. The interim WPAL for BE and NNDPA would be achieved in the aquifer downgradient of the source control wells. Secondary drinking water standards for MN and SO4 would be achieved in the aquifer downgradient of the source control wells. This alternative would not meet chemical-specific ARARs for groundwater beneath the source area until the source is removed or treated in situ. A WPDES (WAC Chapter NR 205) permit issued for discharge of treated groundwater to the Wisconsin River will specify individual discharge limits for each of the groundwater contaminants. It is presumed that this alternative is capable of achieving those limits.
Location-specific	No location-specific ARARs.
Action-specific	Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards. Air emissions from the air strippers would be limited per a permit issued in accordance with WAC Chapter NR 406. An emission limit for each potential air contaminant is identified in WAC Chapter NR 445. In addition, WAC Chapter NR 419 identifies a daily limit for total VOCs emitted from a facility. It is presumed that emission treatment systems associated with the air strippers would meet emission limits.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be implemented prior to implementing this alternative.

TABLE 9-39
DETAILED ANALYSIS - ALTERNATIVE PBG-GW4
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW4 IRM AND AIR STRIPPING - CARBON ADSORPTION
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	This alternative would be implemented to comply with WPALs and secondary drinking water standards. The standards were developed to minimize risk; therefore, the magnitude of the residual risk would be minimal. However, groundwater treatment would not be a permanent solution because it would continue indefinitely unless the source is removed. Therefore, there may be an inherent residual risk unless the source is remediated.
Adequacy and Reliability of Controls	After remedial action objectives have been achieved downgradient of the source control wells, continued operation of the source control wells (assuming the source has not been removed) and groundwater monitoring would ensure the aquifer is not recontaminated. If the source has been removed, long-term monitoring after achieving remedial action objectives for groundwater would not be required.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Air strippers and vapor-phase carbon in the new treatment facility (i.e., air stripping - carbon adsorption treatment facility) would be used for primary treatment of CCL4, CHCL3, TRCLE, and 111TCE. Aqueous-phase carbon in the new facility would be used for polishing CCL4, CHCL3, TRCLE, and 111TCE and removal of 24DNT, 26DNT, and NNDPA. Aqueous-phase carbon followed by air stripper polish would be used in the IRM facility. Thermal reactivation of spent carbon would destroy adsorbed contaminants. Treatment of BE, CR, PB, CD, HG, MN, and SO4 is not expected to be necessary in order to meet surface water discharge limits.
Amount Destroyed or Treated	During the first year of operation, approximately 430 lbs of organic contaminants would be adsorbed in the carbon adsorption systems (i.e., vapor-phase and aqueous-phase systems) at the new facility and the IRM facility and destroyed during thermal reactivation. The mass of contaminants adsorbed and destroyed annually would decrease with each ensuing year because of decreasing contaminant concentrations that result from aquifer flushing.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	The WPDES permit issued for discharge of treated groundwater is expected to require a treatment system removal efficiency of at least 99 percent. Groundwater contaminants adsorbed to the spent carbon would be destroyed during thermal reactivation.
Degree to Which Treatment is Irreversible	Groundwater contaminants would be destroyed during thermal reactivation of spent carbon.

continued

TABLE 9-39
DETAILED ANALYSIS - ALTERNATIVE PBG-GW4
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW4 IRM AND AIR STRIPPING - CARBON ADSORPTION
Type and Quantity of Residuals Remaining After Treatment	Approximately 6,000 lbs of spent vapor-phase carbon and 60,000 lbs of spent aqueous-phase carbon would be generated in the new facility every year. Approximately 120,000 pounds of spent aqueous-phase carbon would be generated in the IRM facility every year. Therefore, a total of approximately 186,000 lbs of spent carbon would be generated annually. Assuming complete destruction of contaminants in the spent carbon during thermal reactivation, no residuals would remain.
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation. There are no residences close enough to the site to be affected by noise or dust generated during construction of the new treatment facility. Contaminants in air stripper emissions would be treated with vapor-phase carbon. Trace quantities may be released into the atmosphere but would be well within safe limits.
Protection of Workers During Remedial Action	With the use of dust suppression techniques and adherence to general health and safety practices during construction, there would be minimal risk to workers.
Environmental Impacts	Adverse impacts to the environment may occur during construction of extraction wells and influent pipelines, particularly in the vicinity of the boundary control wells. Construction in the vicinity of the boundary control wells may require clearing trees which may adversely impact wildlife habitat.
Time Until Remedial Action Objectives Are Achieved	An estimated 41 to 86 years is required to achieve all the remedial action objectives for groundwater downgradient of the source area. Time required for cleanup of groundwater beneath the source area is dependent on remediation of the source area itself.
Implementability	
Ability to Construct and Operate the Technology	Construction of the new facility and modification of the IRM facility would not be difficult. Carbon adsorption (i.e., vapor-phase and aqueous-phase) system operating practices would include replacing carbon at breakthrough <u>or</u> before DNT loading on the carbon exceeds five percent DNTs by weight. The DNT loading limit is enforced by the thermal reactivation facility. However, operation of the existing IRM facility has shown that breakthrough occurs well before the DNT loading limit is exceeded.

continued

TABLE 9-39
DETAILED ANALYSIS - ALTERNATIVE PBG-GW4
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW4 IRM AND AIR STRIPPING - CARBON ADSORPTION
Reliability of the Technology	Air stripping and carbon adsorption are proven technologies for removing organic contaminants from groundwater. The aqueous-phase carbon adsorption system and the air stripper system in the existing IRM facility have been successfully operated for more than three years treating Propellant Burning Ground groundwater. Reversing the systems, as would be done in the new facility, would only make treatment more efficient (i.e., lower carbon usage). Monitoring for contaminant breakthrough between the carbon vessels would ensure that WPDES discharge limits are not exceeded.
Ease of Undertaking Additional Remedial Action, if Necessary	This alternative would not preclude or hinder activities conducted during soil remediation at the Contaminated Waste Area.
Ability to Monitor Effectiveness of Remedy	The effectiveness of the treatment system would be monitored by analysis of samples collected bi-weekly from treatment systems influent and effluent. Aquifer cleanup can be monitored via the groundwater monitoring program.
Ability to Obtain Approvals and Coordinate with Other Agencies	Obtaining a WPDES permit for the discharge of treated groundwater to the Wisconsin River is not expected to be difficult. The existing IRM facility currently operates under a WPDES permit. Sampling and analysis of air stripper emissions may have to be conducted prior to receiving an air permit. Other special permits (e.g., wetland permit) would not be necessary.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Facilities which have sufficient capacity for the reactivation of spent carbon are available.
Availability of Necessary Equipment and Specialists	Air stripping and carbon adsorption equipment and expertise is available from several vendors.
Availability of Technology	Air stripping and carbon adsorption technology for the treatment of groundwater contaminated with chlorinated compounds and explosives is available.
Costs	
Capital Cost	$7,303,000
Present Worth of Operation and Maintenance Cost	$28,260,000
Net Present Worth Cost	$35,563,000

TABLE 9-40
COST SUMMARY TABLE
ALTERNATIVE PBG-GW5: IRM AND RESIN ADSORPTION

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM	TOTAL COST
DIRECT COST OF IRM AND RESIN ADSORPTION	
Site preparation and mob/demob	$ 402,000
Extraction system construction	2,855,000
Resin adsorption treatment facility construction	545,000
Process equipment	3,069,000
Effluent pipe modification	12,000
IRM facility modification	28,000
Treatability testing	48,000
TOTAL DIRECT COST OF IRM AND RESIN ADSORPTION	**$ 6,959,000**
INDIRECT COST OF IRM AND RESIN ADSORPTION	
Health and Safety @ 5% of Total Direct Cost	$ 348,000
Legal, Administration, Permitting @ 5% of Total Direct Cost	348,000
Engineering @ 10% of Total Direct Cost	696,000
Services During Construction @ 10% of Total Direct Cost	696,000
TOTAL INDIRECT COST OF IRM AND RESIN ADSORPTION	**$ 2,088,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$ 9,047,000**
OPERATING AND MAINTENANCE COSTS	
Total cost replacement wells	$ 22,000
Total present worth of replacement wells in year 16, 32, 48 @ 5%	$ 17,000
Total Annual Operating and Maintenance Costs	$ 1,383,000
Total present worth of annual O&M costs (5% for 65 years)	$ 26,500,000
TOTAL PRESENT WORTH OF O&M COSTS	**$ 26,517,000**
TOTAL COST OF IRM AND RESIN ADSORPTION	**$ 35,564,000**

TABLE 9-41
DETAILED ANALYSIS - ALTERNATIVE PBG-GW5
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW5 IRM AND RESIN ADSORPTION
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objectives for human receptors downgradient of the source area (i.e., Contaminated Waste Area). This alternative would both prevent migration of contaminated groundwater off BAAP and reduce contaminant concentrations in groundwater downgradient of the source area to acceptable levels. Remedial action objectives for groundwater beneath the source area would not be achieved until the source is removed or treated in situ.
Environmental Protection	No ecological risks associated with contaminated groundwater.
Compliance with ARARs	
Chemical-specific	The WPAL (WAC Chapter NR 140.10, Table 1) for CCL4, CHCL3, TRCLE, 111TCE, 24DNT, 26DNT, CR, PB, CD, and HG would be achieved in the aquifer downgradient of the source control wells. The interim WPAL for BE and NNDPA would be achieved in the aquifer downgradient of the source control wells. Secondary drinking water standards for MN and SO4 would be achieved in the aquifer downgradient of the source control wells. This alternative would not meet chemical-specific ARARs for groundwater beneath the source area until the source is removed or treated in situ. A WPDES (WAC Chapter NR 205) permit issued for discharge of treated groundwater to the Wisconsin River will specify individual discharge limits for each of the groundwater contaminants. It is presumed that this alternative is capable of achieving those limits.
Location-specific	No location-specific ARARs.
Action-specific	Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be implemented prior to implementing this alternative.

continued

TABLE 9-41
DETAILED ANALYSIS - ALTERNATIVE PBG-GW5
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW5 IRM AND RESIN ADSORPTION
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Extracted groundwater would be treated to comply with WPALs and secondary drinking water standards. The standards were developed to minimize risk; therefore, the magnitude of the residual risk would be minimal. However, groundwater treatment would not be a permanent solution because it would continue indefinitely unless the source is removed. Therefore, there may be an inherent residual risk unless the source is remediated.
Adequacy and Reliability of Controls	After remedial action objectives have been achieved downgradient of the source control wells, continued operation of the source control wells (assuming the source has not been removed) and groundwater monitoring would ensure the aquifer is not recontaminated. If the source has been removed, long-term monitoring after achieving remedial action objectives for groundwater would not be required.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Resin adsorption in the new treatment facility (i.e., resin adsorption treatment facility) would be used to remove CCL4, CHCL3, TRCLE, 111TCE, 24DNT, 26DNT, and NNDPA. Aqueous-phase carbon followed by air stripper polish would be used in the IRM facility. Contaminants in the concentrated organic phase generated during in situ resin regeneration would be destroyed in an incinerator. Thermal reactivation of spent carbon from the IRM facility would destroy adsorbed contaminants. Treatment of BE, CR, PB, CD, HG, MN, and SO4 is not expected to be necessary in order to meet surface water discharge limits.
Amount Destroyed or Treated	During the first year of operation, approximately 430 lbs of organic contaminants would be adsorbed in the resin adsorption system at the new facility and in the carbon adsorption system at the IRM facility and destroyed by incineration and thermal reactivation. The mass of contaminants adsorbed and destroyed annually would decrease with each ensuing year because of decreasing contaminant concentrations that result from aquifer flushing.

continued

TABLE 9-41
DETAILED ANALYSIS - ALTERNATIVE PBG-GW5
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW5 IRM AND RESIN ADSORPTION
Degree of Expected Reductions of Toxicity, Mobility, and Volume	The WPDES permit issued for discharge of treated groundwater is expected to require a treatment system removal efficiency of at least 99 percent. Groundwater contaminants adsorbed to the spent carbon would be destroyed during thermal reactivation.
Degree to Which Treatment is Irreversible	Groundwater contaminants would be destroyed by incineration (organic phase) and thermal reactivation (spent carbon).
Type and Quantity of Residuals Remaining After Treatment	Approximately 350 lbs of concentrated organic phase would be generated in the new facility every year. Approximately 120,000 pounds of spent aqueous-phase carbon would be generated in the IRM facility every year. Assuming complete destruction of the organic phase during incineration and complete destruction of adsorbed contaminants in spent carbon during thermal reactivation, no residuals would remain.
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation. There are no residences close enough to the site to be affected by noise or dust generated during construction of the new treatment facility.
Protection of Workers During Remedial Action	With the use of dust suppression techniques and adherence to general health and safety practices during construction, there would be minimal risk to workers.
Environmental Impacts	Adverse impacts to the environment may occur during construction of extraction wells and influent pipelines, particularly in the vicinity of the boundary control wells. Construction in the vicinity of the boundary control wells may require clearing trees which may adversely impact wildlife habitat.
Time Until Remedial Action Objectives Are Achieved	An estimated 41 to 86 years is required to achieve all the remedial action objectives for groundwater downgradient of the source area. Time required for cleanup of groundwater beneath the source area is dependent on remediation of the source area itself.

continued

TABLE 9-41
DETAILED ANALYSIS - ALTERNATIVE PBG-GW5
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW5 IRM AND RESIN ADSORPTION
Implementability	
Ability to Construct and Operate the Technology	Construction of the new facility and modification of the IRM facility would not be difficult. Resin adsorption system operating practices would include regenerating resin at breakthrough. Resin regeneration requires forcing steam through the spent resin bed and separating the organic phase from the aqueous phase in the condensate. Consequently, auxiliary systems associated with the resin adsorption system are extensive. IRM facility carbon adsorption system operating practices would include replacing carbon at breakthrough or before DNT loading on the carbon exceeds five percent DNTs by weight. The DNT loading limit is enforced by the thermal reactivation facility. However, operation of the existing IRM facility has shown that breakthrough occurs well before the DNT loading limit is exceeded.
Reliability of the Technology	Resin adsorption is not a proven technology for removing chlorinated compounds and explosives from groundwater. Resin technology applied to treatment of water contaminated with chlorinated compounds is being developed but has not been implemented at full scale. Treatability testing conducted to date indicates that hydrochloric acid is generated during steam regeneration of resin contaminated with adsorbed chlorinated compounds (Lynch, 1993). Hydrochloric acid may accelerate treatment system corrosion. Also, it is not known whether 24DNT will condense into the concentrated organic phase during resin regeneration. These and other concerns would be evaluated during extensive treatability testing. The IRM facility has proven to be effective for treatment of Propellant Burning Ground groundwater. Monitoring for contaminant breakthrough between the resin vessels (new facility) and carbon vessels (IRM facility) would ensure that WPDES discharge limits are not exceeded.
Ease of Undertaking Additional Remedial Action, if Necessary	This alternative would not preclude or hinder activities conducted during soil remediation at the Contaminated Waste Area.
Ability to Monitor Effectiveness of Remedy	The effectiveness of the treatment system would be monitored by analysis of samples collected bi-weekly from treatment systems influent and effluent. Aquifer cleanup can be monitored via the groundwater monitoring program.

continued

TABLE 9-41
DETAILED ANALYSIS - ALTERNATIVE PBG-GW5
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW5 IRM AND RESIN ADSORPTION
Ability to Obtain Approvals and Coordinate with Other Agencies	Obtaining a WPDES permit for the discharge of treated groundwater to the Wisconsin River is not expected to be difficult. The existing IRM facility currently operates under a WPDES permit. Other special permits (e.g., wetland permit) would not be necessary.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Facilities which have sufficient capacity for incineration of concentrated organic phase and reactivation of spent carbon are available.
Availability of Necessary Equipment and Specialists	Availability of resin adsorption equipment manufacturers and specialists versed in system design and operation is limited.
Availability of Technology	Resin adsorption technology for the treatment of chlorinated compounds is being developed. Information concerning resin treatment of explosives is unavailable.
Costs	
Capital Cost	$9,047,000
Present Worth of Operation and Maintenance Cost	$26,517,000
Net Present Worth Cost	$35,564,000

TABLE 9-42
COST SUMMARY TABLE
ALTERNATIVE PBG-GW7: IRM AND UV REDUCTION-CARBON ADSORPTION

FEASIBILITY STUDY
PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF IRM AND UV REDUCTION-CARBON ADSORPTION		
Site preparation and mob/demob	$	402,000
Extraction system construction		2,855,000
UV reduction-carbon adsorption treatment facility construction		719,000
Process equipment		2,474,000
Effluent pipe modification		12,000
IRM facility modification		28,000
Treatability testing		6,000
TOTAL DIRECT COST OF IRM AND UV REDUCTION-CARBON ADSORPTION	**$**	**6,496,000**
INDIRECT COST OF IRM AND UV REDUCTION-CARBON ADSORPTION		
Health and Safety @ 5% of Total Direct Cost	$	325,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		325,000
Engineering @ 10% of Total Direct Cost		650,000
Services During Construction @ 10% of Total Direct Cost		650,000
TOTAL INDIRECT COST OF IRM AND UV REDUCTION-CARBON ADSORPTION	**$**	**1,950,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**8,446,000**
OPERATING AND MAINTENANCE COSTS		
Total cost replacement wells	$	22,000
Total present worth of replacement wells in year 16, 32, 48 @ 5%	$	17,000
Total Annual Operating and Maintenance Costs	$	2,056,000
Total present worth of annual O&M costs (5% for 65 years)	$	31,606,000
TOTAL PRESENT WORTH OF O&M COSTS	**$**	**31,623,000**
TOTAL COST FOR IRM AND UV REDUCTION-CARBON ADSORPTION	**$**	**40,069,000**

TABLE 9-43
DETAILED ANALYSIS - ALTERNATIVE PBG-GW7
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW7 IRM AND UV REDUCTION - CARBON ADSORPTION
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objectives for human receptors downgradient of the source area (i.e., Contaminated Waste Area). This alternative would both prevent migration of contaminated groundwater off BAAP and reduce contaminant concentrations in groundwater downgradient of the source area to acceptable levels. Remedial action objectives for groundwater beneath the source area would not be achieved until the source is removed or treated in situ.
Environmental Protection	No ecological risks associated with contaminated groundwater.
Compliance with ARARs	
Chemical-specific	The WPAL (WAC Chapter NR 140.10, Table 1) for CCL4, CHCL3, TRCLE, 111TCE, 24DNT, 26DNT, CR, PB, CD, and HG would be achieved in the aquifer downgradient of the source control wells. The interim WPAL for BE and NNDPA would be achieved in the aquifer downgradient of the source control wells. Secondary drinking water standards for MN and SO4 would be achieved in the aquifer downgradient of the source control wells. This alternative would not meet chemical-specific ARARs for groundwater beneath the source area until the source is removed or treated in situ. A WPDES (WAC Chapter NR 205) permit issued for discharge of treated groundwater to the Wisconsin River will specify individual discharge limits for each of the groundwater contaminants. It is presumed that this alternative is capable of achieving those limits.
Location-specific	No location-specific ARARs.
Action-specific	Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be implemented prior to implementing this alternative.

continued

TABLE 9-43
DETAILED ANALYSIS - ALTERNATIVE PBG-GW7
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW7 IRM AND UV REDUCTION - CARBON ADSORPTION
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Extracted groundwater would be treated to comply with WPALs and secondary drinking water standards. The standards were developed to minimize risk; therefore, the magnitude of the residual risk would be minimal. However, groundwater treatment would not be a permanent solution because it would continue indefinitely unless the source is removed. Therefore, there may be an inherent residual risk unless the source is remediated.
Adequacy and Reliability of Controls	After remedial action objectives have been achieved downgradient of the source control wells, continued operation of the source control wells (assuming the source has not been removed) and groundwater monitoring would ensure the aquifer is not recontaminated. If the source has been removed, long-term monitoring after achieving remedial action objectives for groundwater would not be required.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	UV reduction in the new treatment facility (i.e., UV reduction - carbon adsorption treatment facility) would be used for total destruction of CCL4, CHCL3, TRCLE, and 111TCE. Partial destruction of 24DNT, 26DNT, and NNDPA would occur in the UV reduction system and polishing would occur in the carbon adsorption system. Aqueous-phase carbon followed by air stripper polish would be used in the IRM facility. Thermal reactivation of spent carbon from the IRM facility would destroy adsorbed contaminants. Treatment of BE, CR, PB, CD, HG, MN, and SO4 is not expected to be necessary in order to meet surface water discharge limits.
Amount Destroyed or Treated	During the first year of operation, approximately 430 lbs of organic contaminants would be destroyed by UV reduction at the new facility and adsorbed in the carbon adsorption systems at the new facility and the IRM facility. Contaminants adsorbed to spent carbon would be destroyed during thermal reactivation. The mass of contaminants destroyed annually would decrease with each ensuing year because of decreasing contaminant concentrations that result from aquifer flushing.

continued

Table 9-43
Detailed Analysis - Alternative PBG-GW7
Propellant Burning Ground Groundwater

Feasibility Study
Badger Army Ammunition Plant

Evaluation Criteria	Alternative PBG-GW7 IRM and UV Reduction - Carbon Adsorption
Degree of Expected Reductions of Toxicity, Mobility, and Volume	The WPDES permit issued for discharge of treated groundwater is expected to require a treatment system removal efficiency of at least 99 percent. Groundwater contaminants adsorbed to the spent carbon would be destroyed during thermal reactivation.
Degree to Which Treatment is Irreversible	Groundwater contaminants would be destroyed by on-site UV reduction and off-site thermal reactivation of spent carbon.
Type and Quantity of Residuals Remaining After Treatment	Approximately 60,000 lbs of spent carbon would be generated in the new facility after 50 years of treatment. Approximately 120,000 pounds of spent aqueous-phase carbon would be generated in the IRM facility every year. Assuming complete destruction of contaminants by UV reduction and thermal regeneration of spent carbon, no residuals would remain.
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation. There are no residences close enough to the site to be affected by noise or dust generated during construction of the new treatment facility.
Protection of Workers During Remedial Action	With the use of dust suppression techniques and adherence to general health and safety practices during construction, there would be minimal risk to workers. The chemical additive used during UV reduction has actually been approved by the Food and Drug Administration as a food additive and so would not present a hazard to treatment plant operators.
Environmental Impacts	Adverse impacts to the environment may occur during construction of extraction wells and influent pipelines, particularly in the vicinity of the boundary control wells. Construction in the vicinity of the boundary control wells may require clearing trees which may adversely impact wildlife habitat.
Time Until Remedial Action Objectives Are Achieved	An estimated 41 to 86 years is required to achieve all the remedial action objectives for groundwater downgradient of the source area. Time required for cleanup of groundwater beneath the source area is dependent on remediation of the source area itself.

continued

TABLE 9-43
DETAILED ANALYSIS - ALTERNATIVE PBG-GW7
PROPELLANT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW7 IRM AND UV REDUCTION - CARBON ADSORPTION
Implementability	
Ability to Construct and Operate the Technology	Construction of the new facility and modification of the IRM facility would not be difficult. UV reduction operating practices would include filling the additive storage tank every 10 days and replacement of UV lamps every four months. Carbon adsorption system operating practices in the IRM facility would include replacing carbon at breakthrough <u>or</u> before DNT loading on the carbon exceeds five percent DNTs by weight. The DNT loading limit is enforced by the thermal reactivation facility. However, operation of the existing IRM facility has shown that breakthrough occurs well before the DNT loading limit is exceeded. It is expected that DNT loading on carbon in the new facility would exceed 5 percent after 50 years of operation. Consequently, the spent carbon would be blended with another material and incinerated.
Reliability of the Technology	Results from bench- and pilot-scale testing of UV reduction indicate that it has significant potential for treatment of water contaminated with chlorinated compounds. Considerable treatability study work may be required to adapt the technology to treat a particular wastestream (Woeller, 1993). The first full-scale UV reduction groundwater treatment facility is currently under construction at Kennedy Space Center, FL (Nolan, 1993). The IRM facility has proven to be effective for treatment of Propellant Burning Ground groundwater. Monitoring for contaminant breakthrough between the carbon vessels at the new facility and the IRM facility would ensure that WPDES discharge limits are not exceeded.
Ease of Undertaking Additional Remedial Action, if Necessary	This alternative would not preclude or hinder activities conducted during soil remediation at the Contaminated Waste Area.
Ability to Monitor Effectiveness of Remedy	The effectiveness of the treatment system would be monitored by analysis of samples collected bi-weekly from treatment systems influent and effluent. Aquifer cleanup can be monitored via the groundwater monitoring program.
Ability to Obtain Approvals and Coordinate with Other Agencies	Obtaining a WPDES permit for the discharge of treated groundwater to Lake Wisconsin is not expected to be difficult. The existing IRM facility currently operates under a WPDES permit. Other special permits (e.g., wetland permit) would not be necessary.

continued

TABLE 9-43
DETAILED ANALYSIS - ALTERNATIVE PBG-GW7
PROPELLANT BURNING GROUND GROUNDWATER

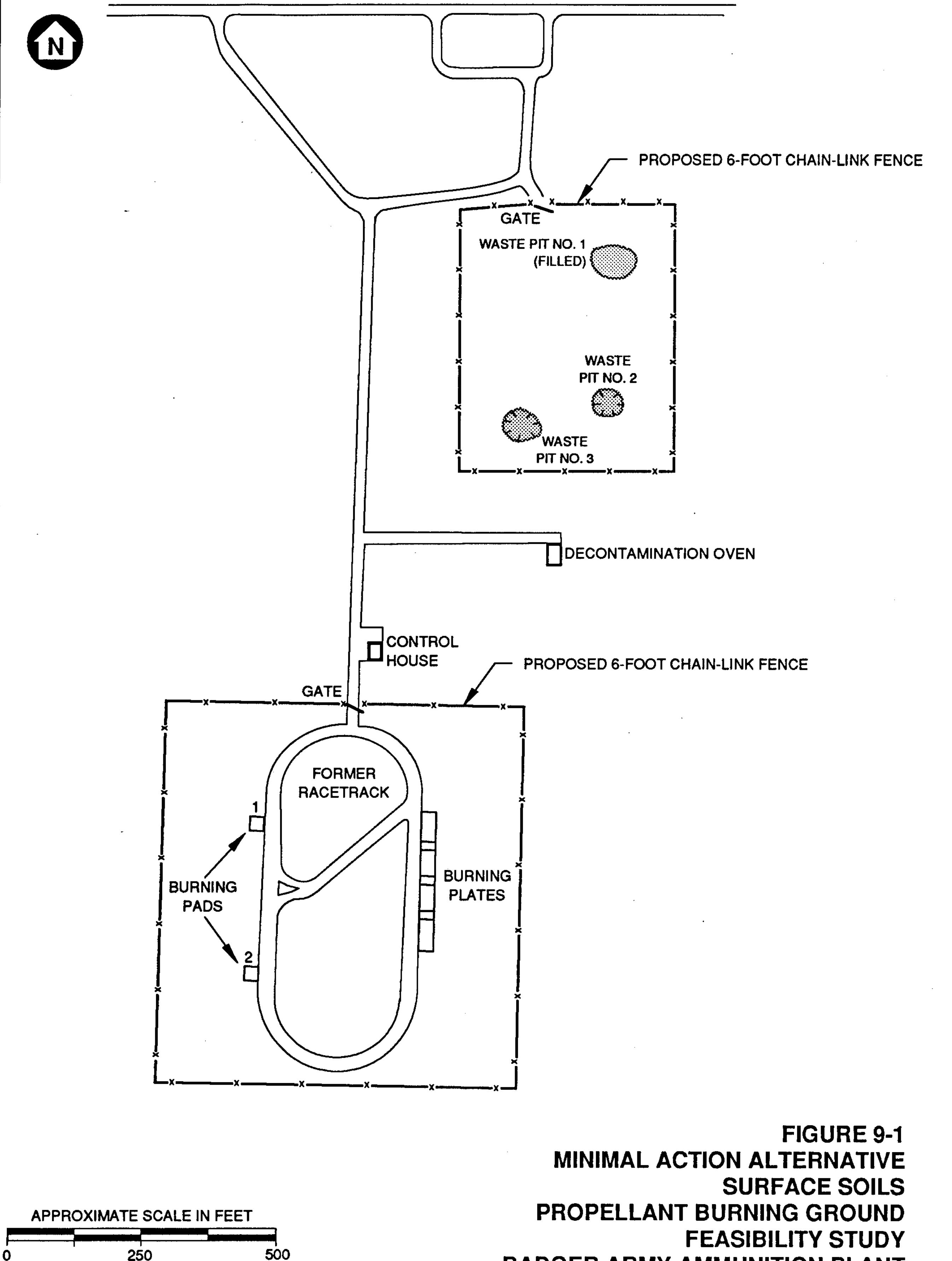
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE PBG-GW7 IRM AND UV REDUCTION - CARBON ADSORPTION
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Facilities which have sufficient capacity for reactivation or incineration of spent carbon are available.
Availability of Necessary Equipment and Specialists	Availability of UV reduction equipment manufacturers and specialists versed in system design and operation is limited.
Availability of Technology	UV reduction technology for the treatment of chlorinated compounds has been developed.
Costs	
Capital Cost	$8,446,000
Present Worth of Operation and Maintenance Cost	$31,623,000
Net Present Worth Cost	$40,069,000

Table 9-44
Comparative Summary of Groundwater Alternatives
Propellant Burning Ground Groundwater

Feasibility Study
Badger Army Ammunition Plant

Alternative	Overall Protection	Compliance with ARARs	Effectiveness: Long-Term	Reduction in Toxicity, Mobility, and Volume	Effectiveness: Short-Term	Implementability	Cost
Alternative PBG-GW1: Minimal Action	Not protective of human health. Groundwater contaminant concentrations may increase and plume's areal extent would expand.	Would not achieve WPALs. Location-specific and action-specific ARARs do not apply.	Not applicable because remedial action objectives are not achieved.	Contamination is not treated or destroyed; no reduction of toxicity, mobility, or volume of contaminants.	No adverse community or environmental impacts during implementation	No implementability concerns.	Total Present Worth: $7,442,000 Capital Cost: $10,000 Annual O&M: $387,000
Alternative PBG-GW2: IRM and Carbon Adsorption	Achieves remedial action objectives for human receptors downgradient of the Contaminated Waste Area.	Would achieve WPALs in aquifer downgradient of source control wells. Capable of achieving WPDES permit limits.	Residual risk would be minimal downgradient of source control wells. Inherent residual risk unless source is remediated.	Removal efficiency greater than 99%. Approximately 360,000 lbs of spent carbon generated annually. Off-site destruction of contaminants.	No adverse impacts to community. Potentially adverse impacts to environment during construction of extraction system.	No implementability concerns. Technologies have been proven full-scale. No problems expected permitting discharge.	Total Present Worth: $35,040,000 Capital Cost: $6,569,000 Annual O&M: $1,485,000
Alternative PBG-GW4: IRM and Air Stripping - Carbon Adsorption	Achieves remedial action objectives for human receptors downgradient of the Contaminated Waste Area.	Would achieve WPALs in aquifer downgradient of source control wells. Capable of achieving WPDES and air permits limits.	Residual risk would be minimal downgradient of source control wells. Inherent residual risk unless source is remediated.	Removal efficiency greater than 99%. Approximately 186,000 lbs of spent carbon generated annually. Off-site destruction of contaminants.	No adverse impacts to community. Potentially adverse impacts to environment during construction of extraction system.	No implementability concerns. Technologies have been proven full-scale. No problems expected permitting discharge or air emissions.	Total Present Worth: $35,563,000 Capital Cost: $7,303,000 Annual O&M: $1,474,000
Alternative PBG-GW5: IRM and Resin Adsorption	Achieves remedial action objectives for human receptors downgradient of the Contaminated Waste Area.	Would achieve WPALs in aquifer downgradient of source control wells. Capable of achieving WPDES permit limits.	Residual risk would be minimal downgradient of source control wells. Inherent residual risk unless source is remediated.	Removal efficiency greater than 99%. Approximately 350 lbs of organic phase and 120,000 lbs of spent carbon generated annually. Off-site destruction of contaminants.	No adverse impacts to community. Potentially adverse impacts to environment during construction of extraction system.	Significant implementability concerns. Resin technology has not been proven full-scale and extensive treatability testing would be required. No problems expected permitting discharge.	Total Present Worth: $35,564,000 Capital Cost: $9,047,000 Annual O&M: $1,383,000
Alternative PBG-GW7: IRM and UV Reduction - Carbon Adsorption	Achieves remedial action objectives for human receptors downgradient of the Contaminated Waste Area.	Would achieve WPALs in aquifer downgradient of source control wells. Capable of achieving WPDES permit limits.	Residual risk would be minimal downgradient of source control wells. Inherent residual risk unless source is remediated.	Destruction and removal efficiency greater than 99%. Approximately 120,000 lbs of spent carbon generated annually. On-site and off-site destruction of contaminants.	No adverse impacts to community. Potentially adverse impacts to environment during construction of extraction system.	Minor implementability concerns. Treatability studies required to adapt UV reduction to the wastestream. No problems expected permitting discharge.	Total Present Worth: $40,069,000 Capital Cost: $8,446,000 Annual O&M: $2,056,000



Source: Modified from Tsai, et.al., 1988.

FIGURE 9-1
MINIMAL ACTION ALTERNATIVE
SURFACE SOILS
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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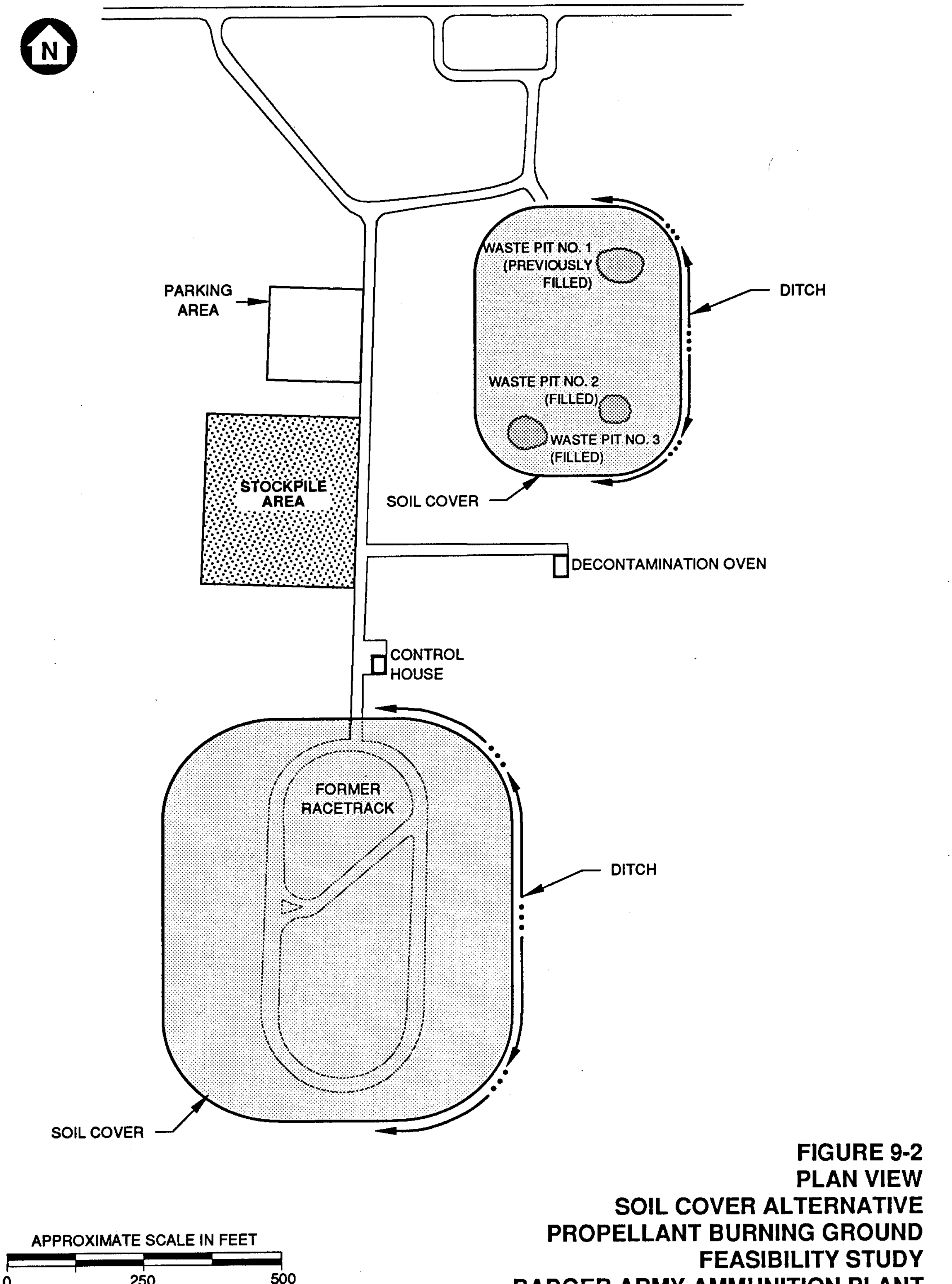

Source: Modified from Tsai, et.al., 1988.

FIGURE 9-2
PLAN VIEW
SOIL COVER ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

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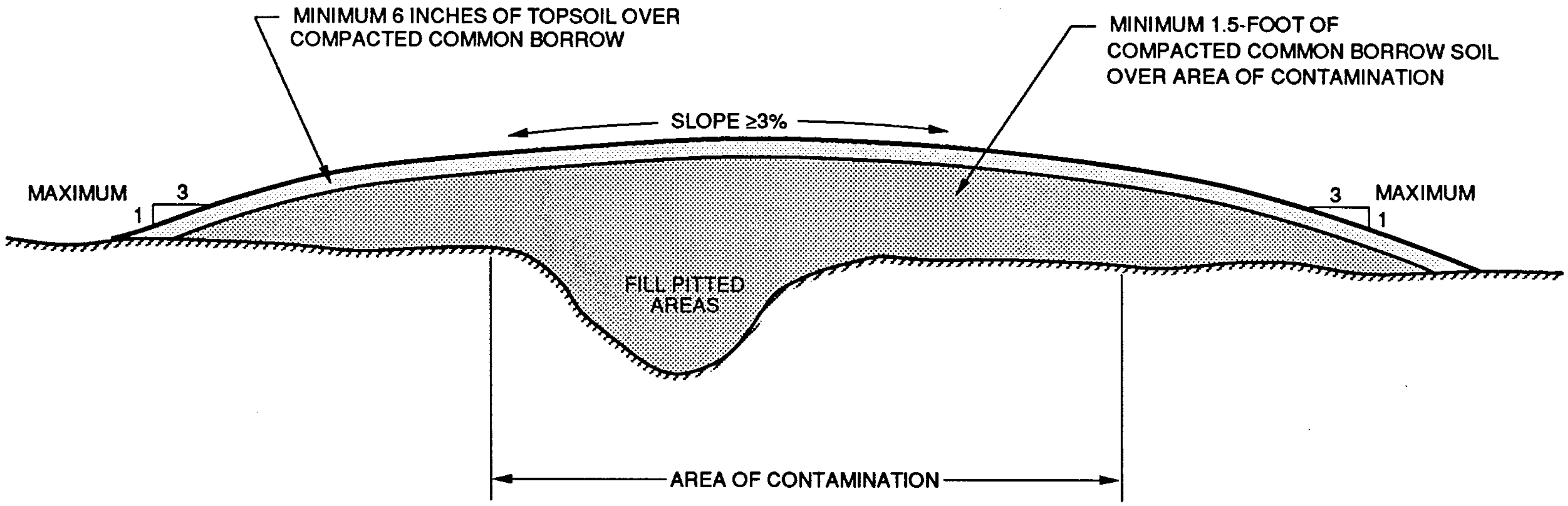

NOT TO SCALE

FIGURE 9-3
TYPICAL SOIL COVER CROSS SECTION
SOIL COVER ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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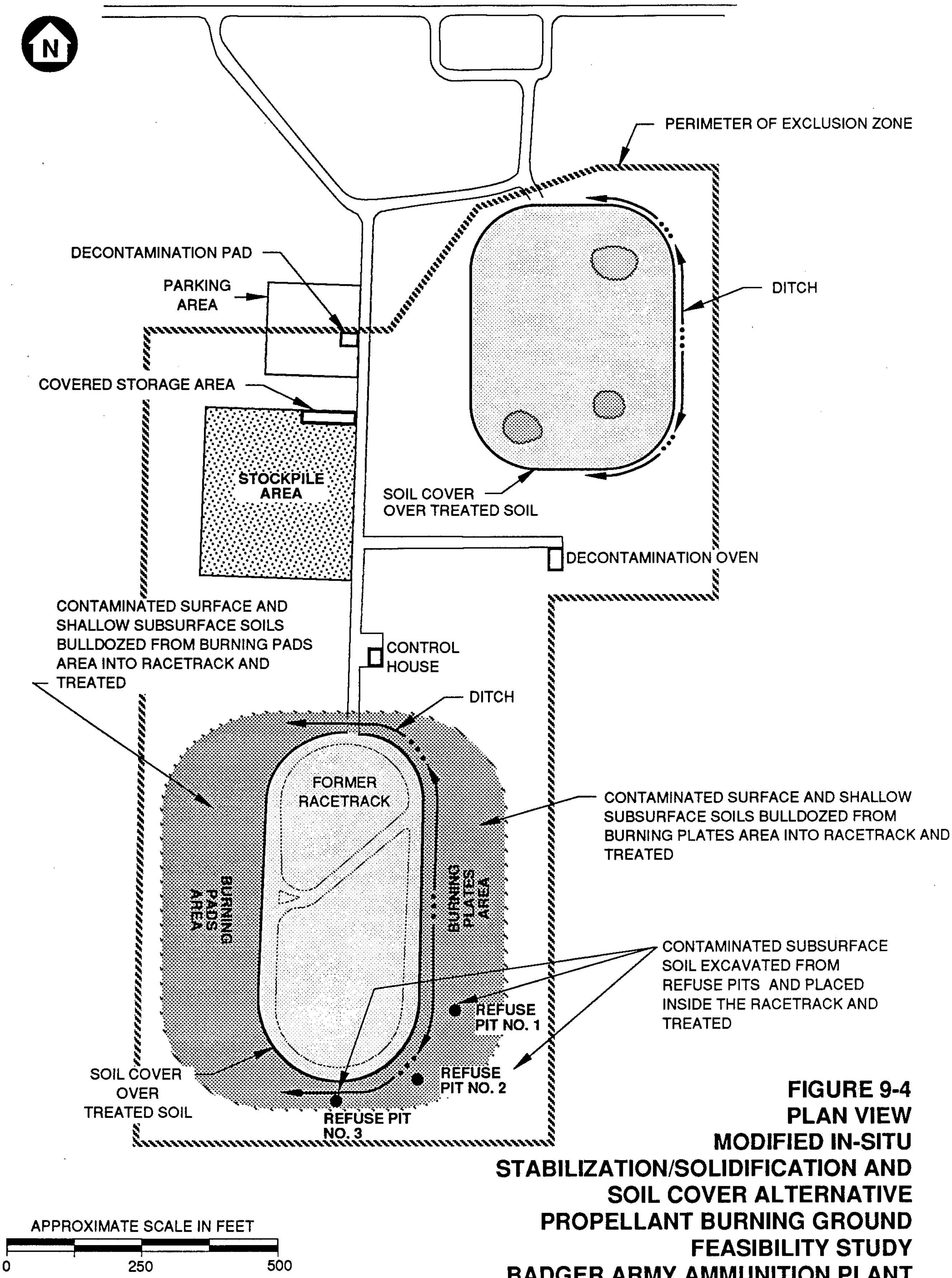

Source: Modified from Tsai, et.al., 1988.

FIGURE 9-4
PLAN VIEW
MODIFIED IN-SITU STABILIZATION/SOLIDIFICATION AND SOIL COVER ALTERNATIVE
PROPELLANT BURNING GROUND FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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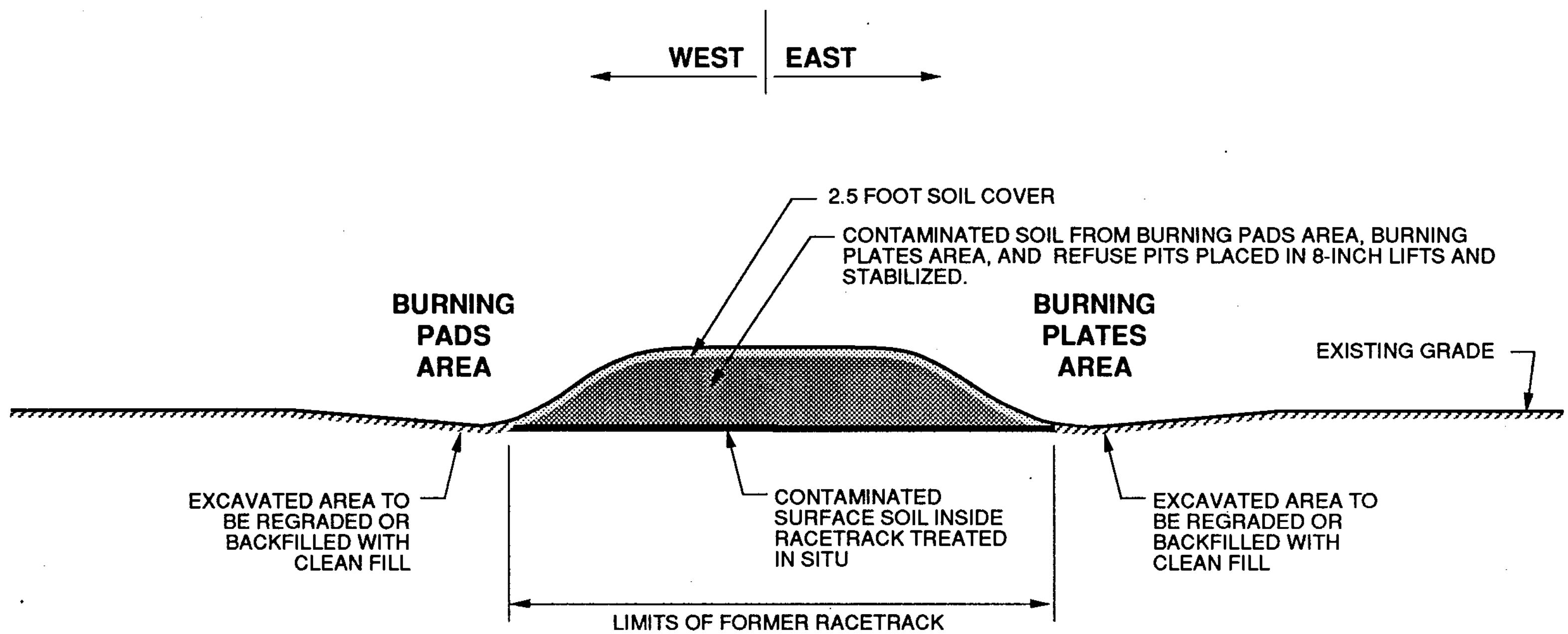

NOT TO SCALE

FIGURE 9-5
TYPICAL CROSS SECTION
IN SITU STABILIZATION/SOLIDIFICATION AND SOIL COVER ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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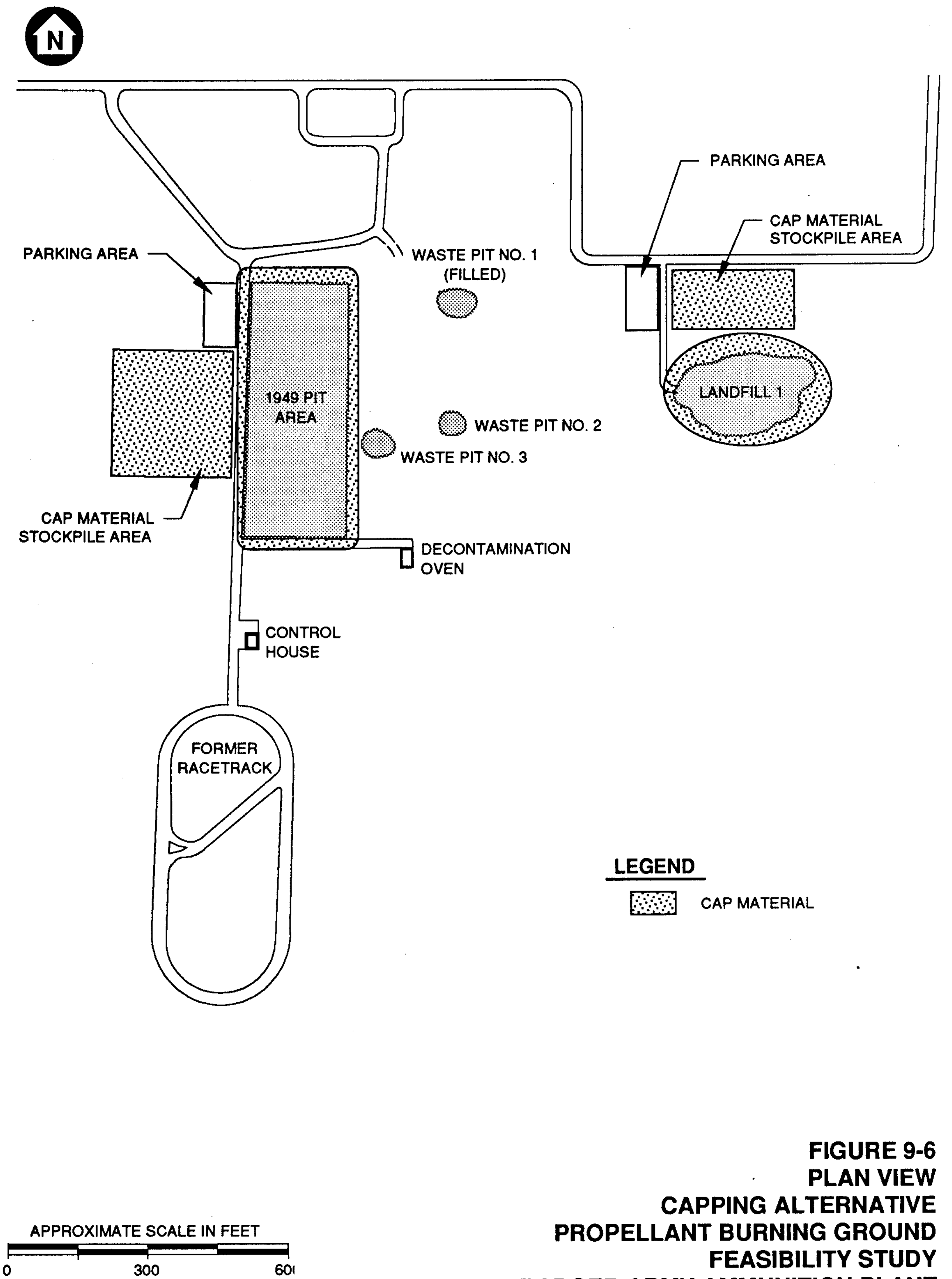

Source: Modified from Tsai, et.al., 1988.

FIGURE 9-6
PLAN VIEW
CAPPING ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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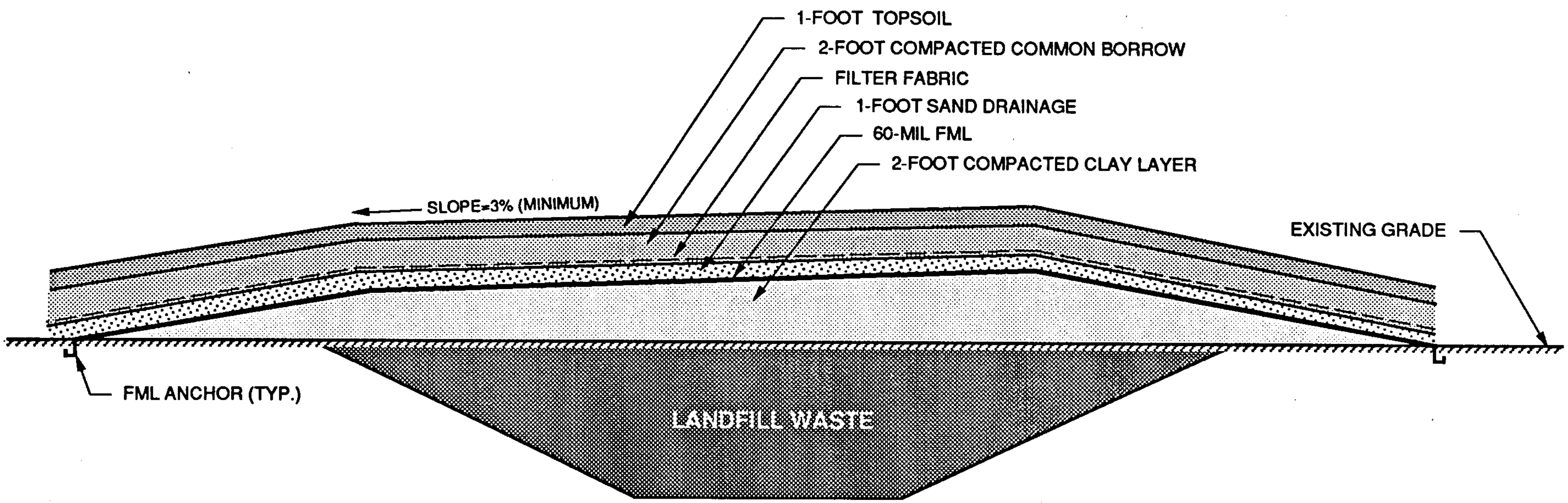

NOTES:
FML = FLEXIBLE MEMBRANE LINER

NOT TO SCALE

FIGURE 9-7
TYPICAL CROSS SECTION
CAPPING ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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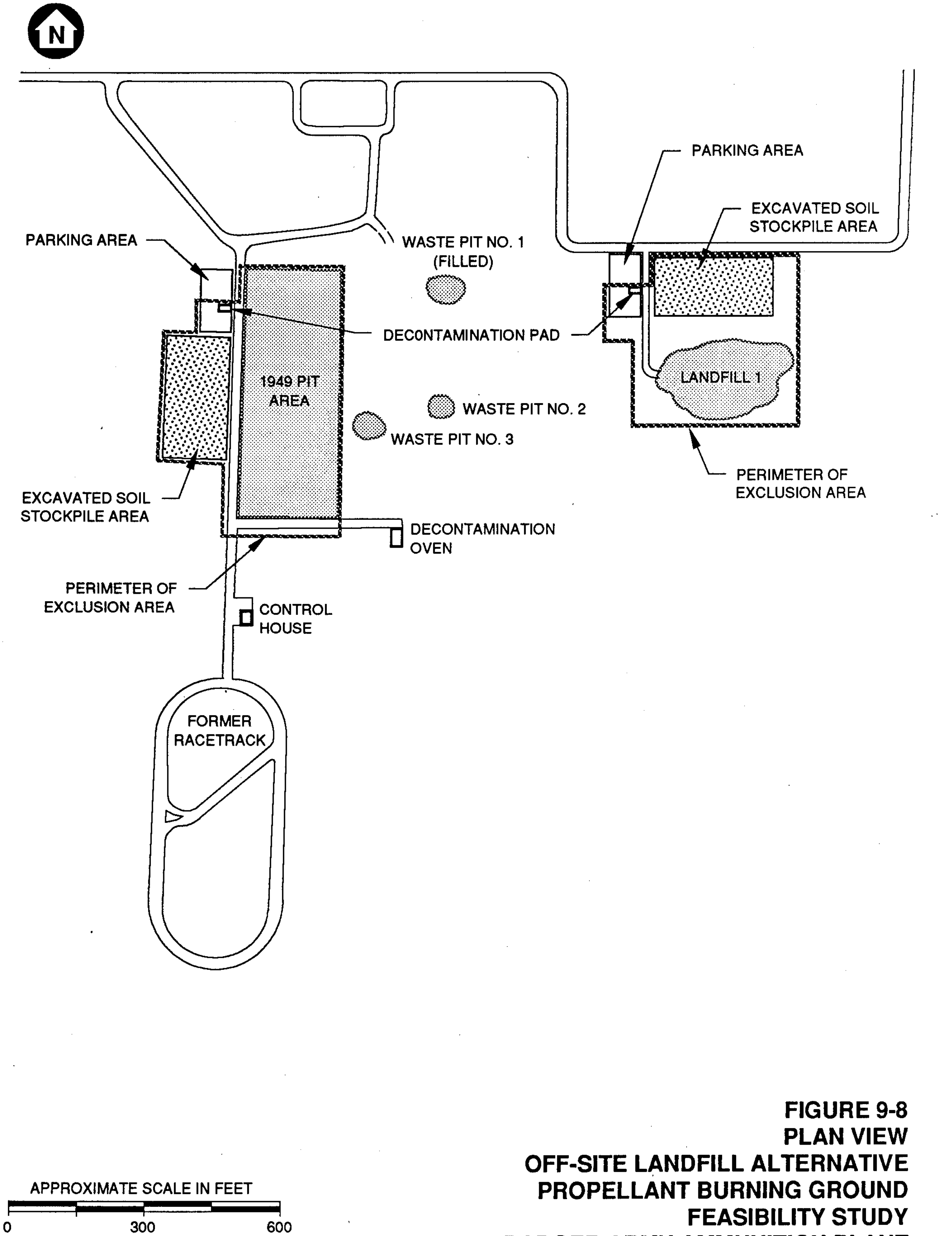

Source: Modified from Tsai, et.al., 1988.

FIGURE 9-8
PLAN VIEW
OFF-SITE LANDFILL ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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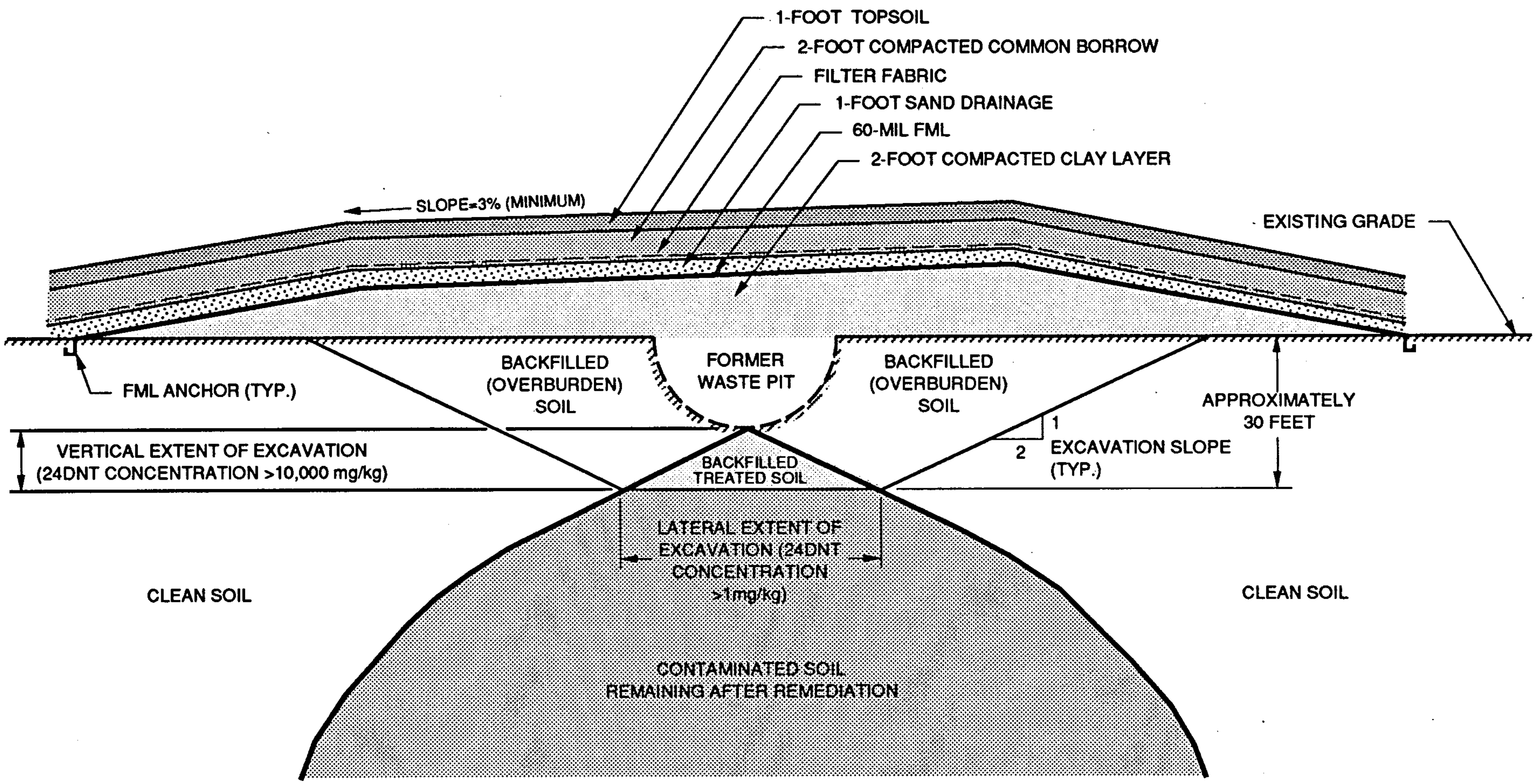

NOTES:
FML = FLEXIBLE MEMBRANE LINER
mg/kg = MILLIGRAMS PER KILOGRAM

NOT TO SCALE

FIGURE 9-9
TYPICAL CROSS SECTION
ON-SITE INCINERATION AND CAPPING ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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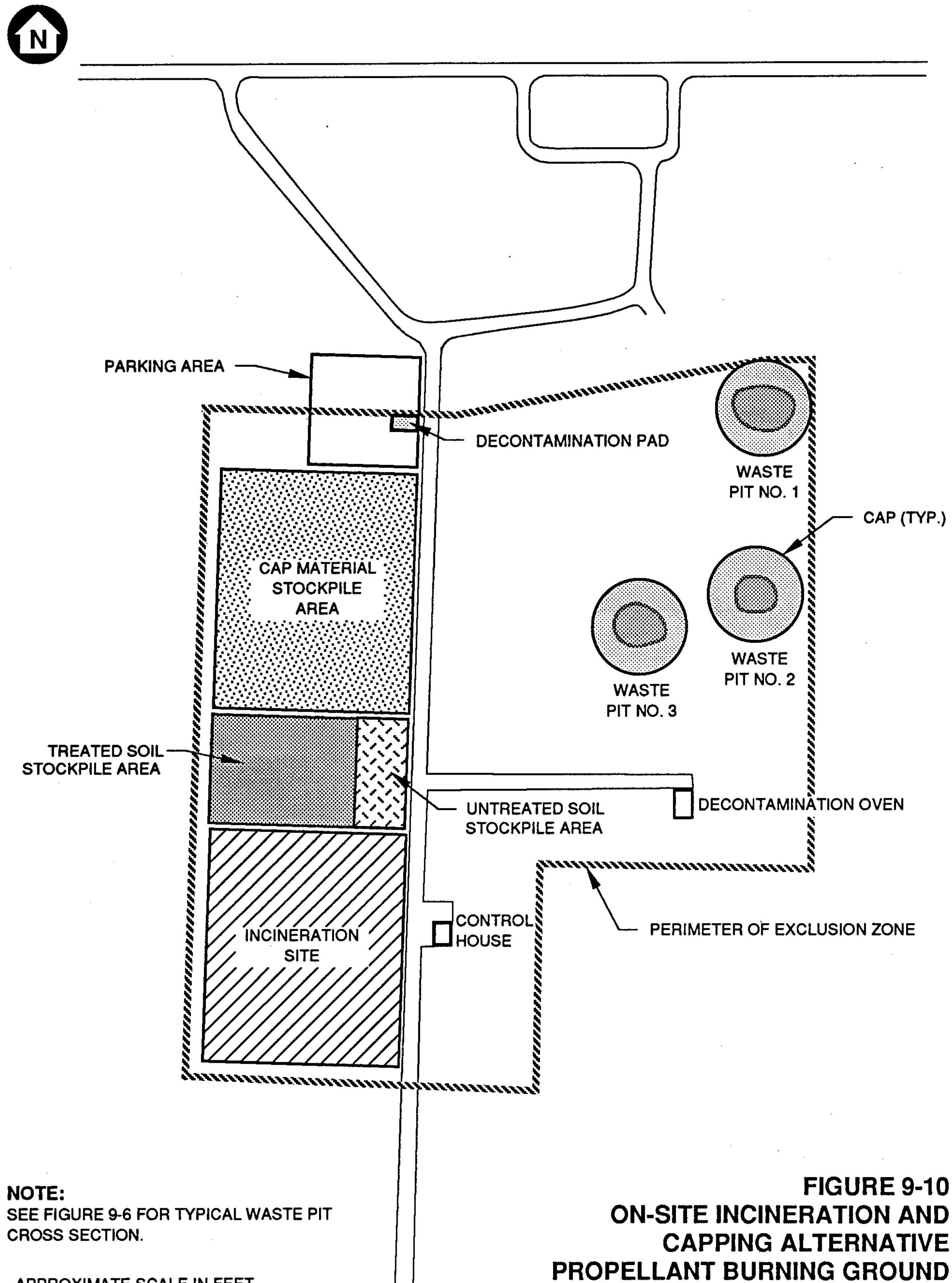

NOTE:
SEE FIGURE 9-6 FOR TYPICAL WASTE PIT CROSS SECTION.

APPROXIMATE SCALE IN FEET

0 200 400

Source: Modified from Tsai, et.al., 1988.

FIGURE 9-10
ON-SITE INCINERATION AND CAPPING ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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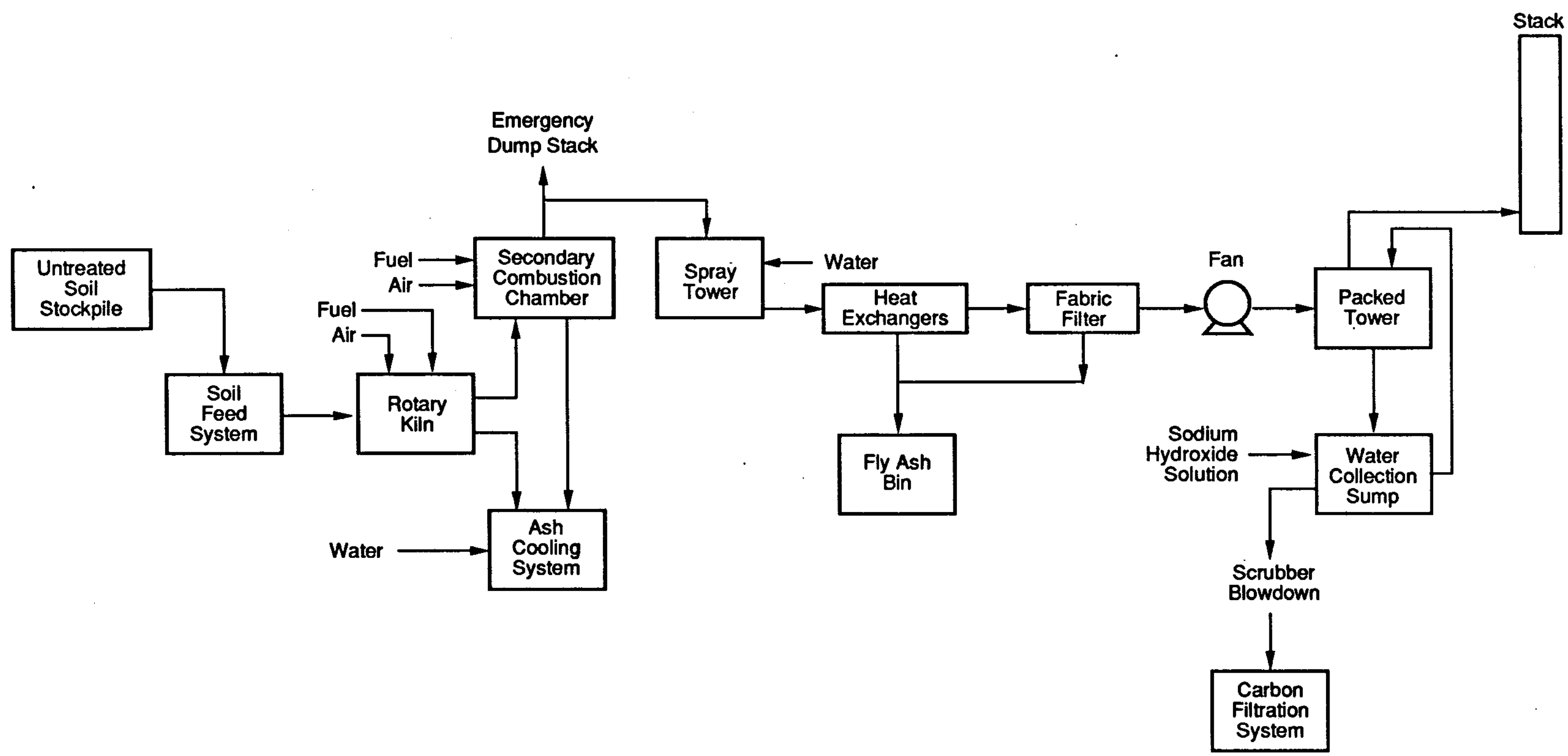

FIGURE 9-11
TIS-20 PROCESS FLOW SCHEMATIC
ON-SITE INCINERATION AND CAPPING ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

SOURCE: JOHNSON, N.P. AND COSMOS, M.G., 1989.

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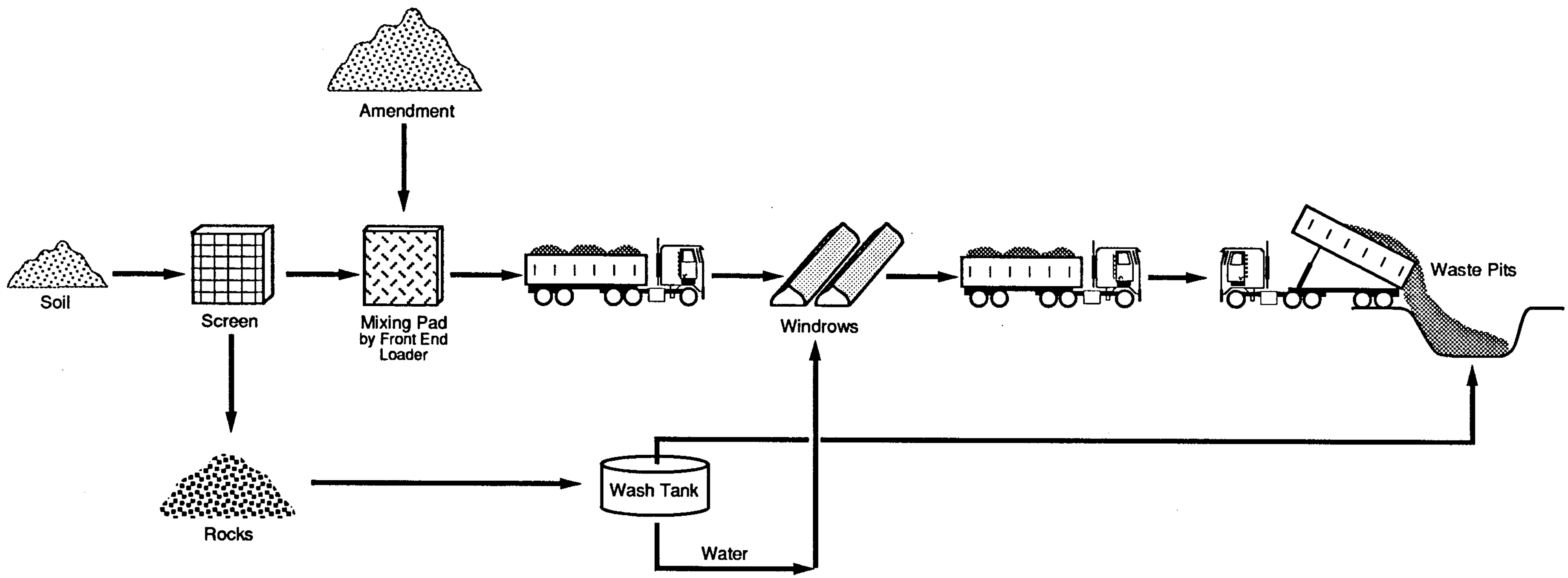

FIGURE 9-12
COMPOSTING SYSTEM FLOW DIAGRAM
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

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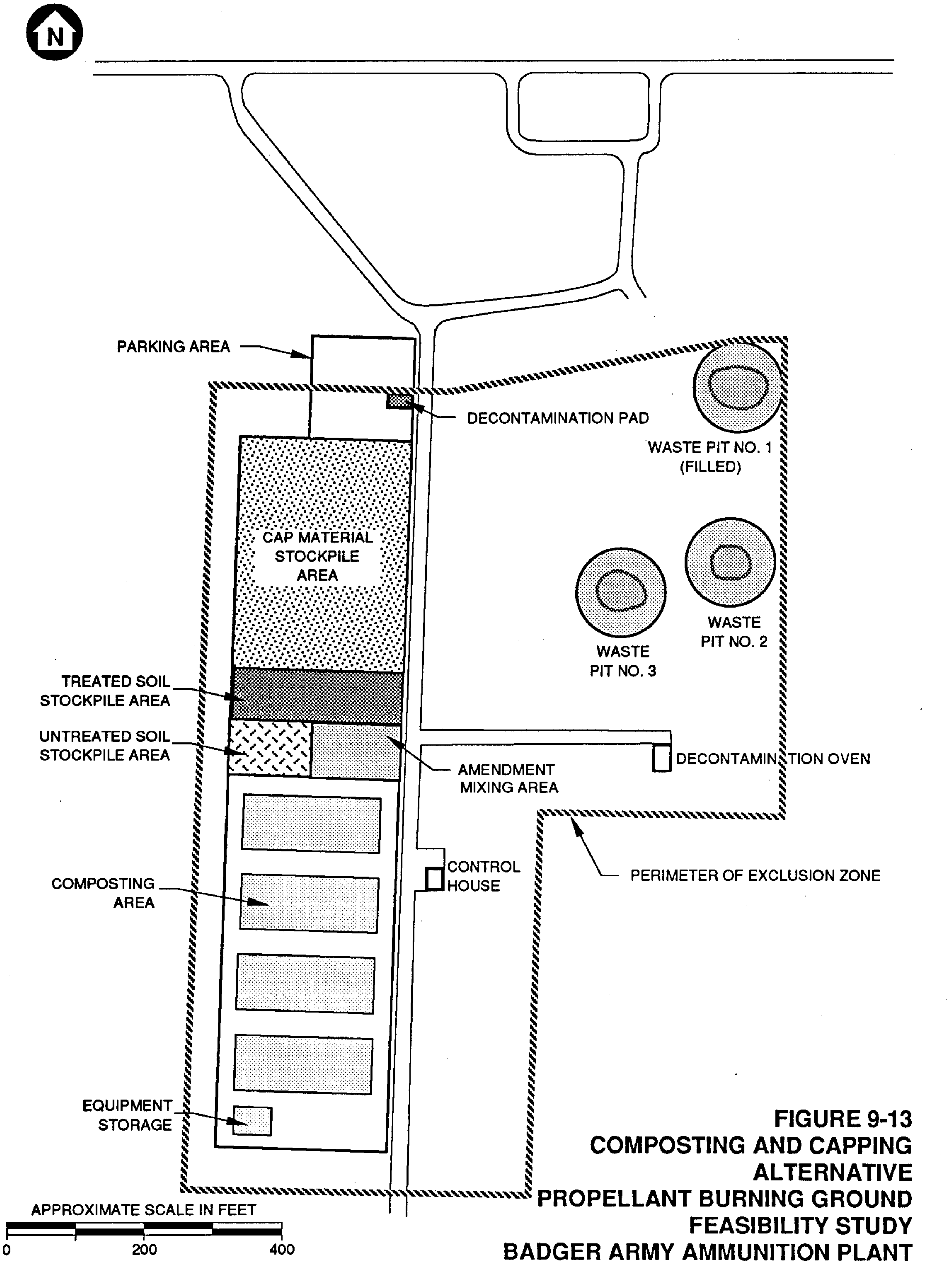

Source: Modified from Tsai, et.al., 1988.

FIGURE 9-13
COMPOSTING AND CAPPING ALTERNATIVE
PROPELLANT BURNING GROUND FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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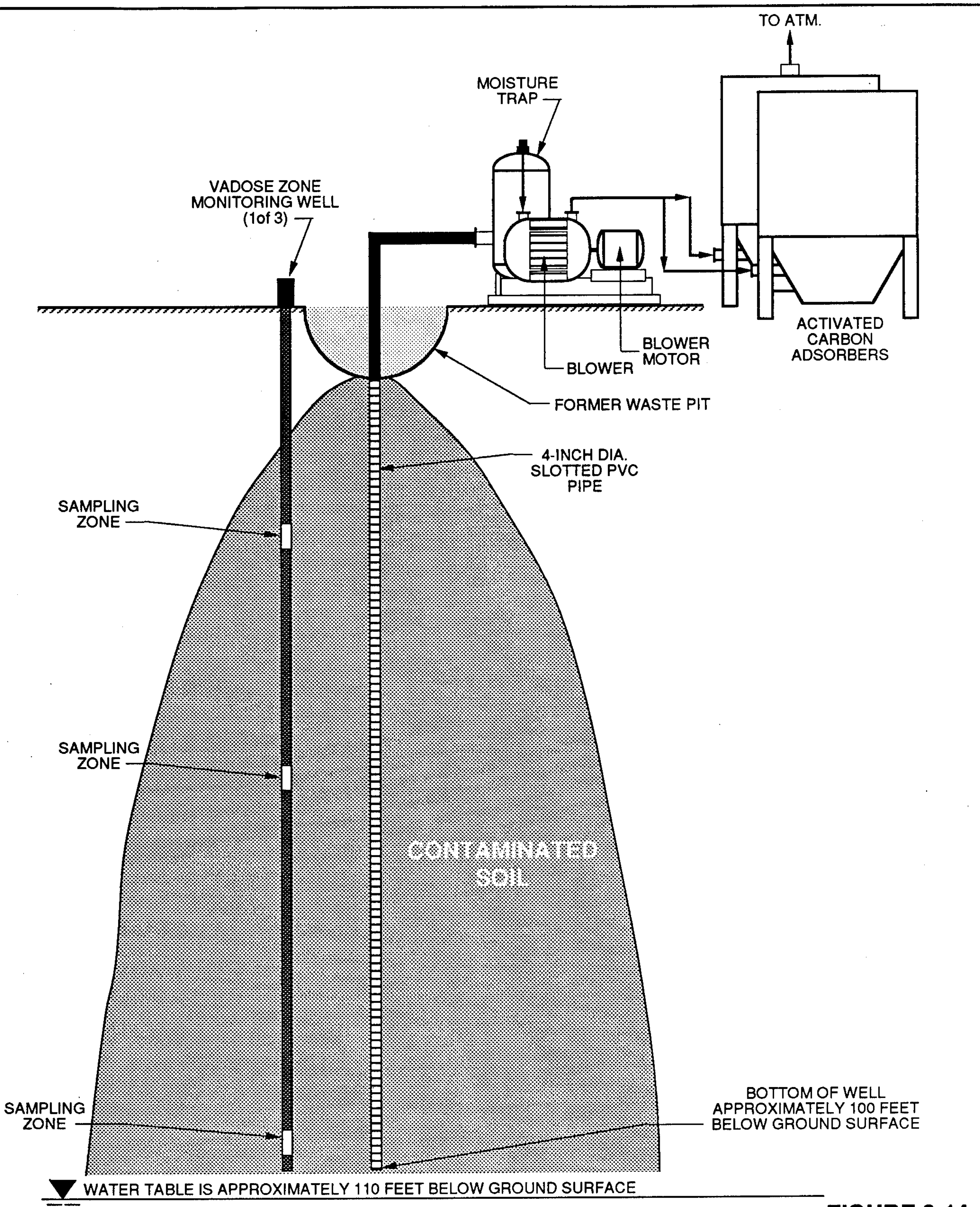

FIGURE 9-14
IN SITU VACUUM EXTRACTION SYSTEM
IN SITU VACUUM EXTRACTION, COMPOSTING AND CAPPING ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

NOT TO SCALE

ABB Environmental Services, Inc.

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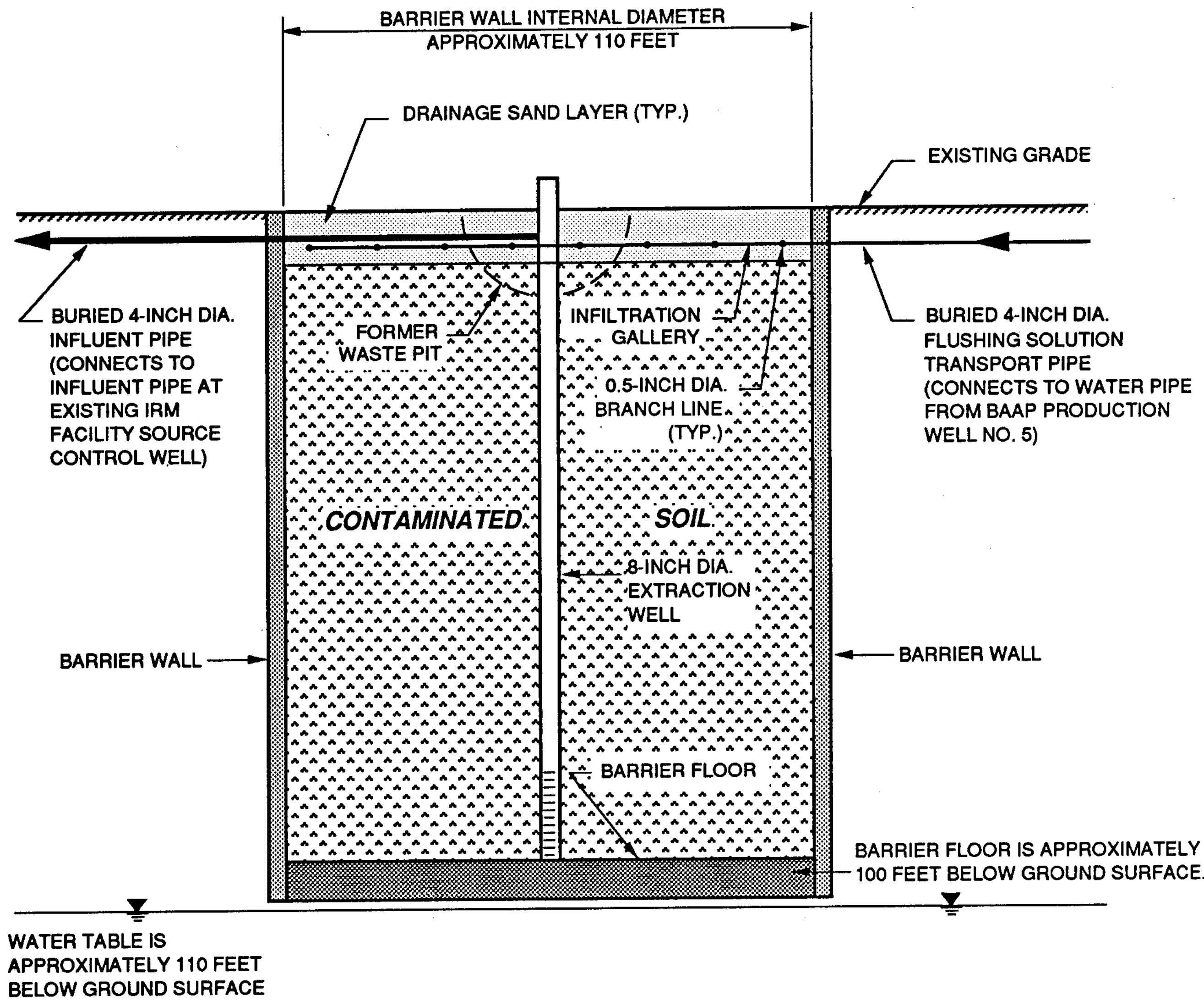

NOTE:
BAAP = BADGER ARMY AMMUNITION PLANT

NOT TO SCALE

FIGURE 9-15
TYPICAL CROSS SECTION-SOIL FLUSHING IN SITU TREATMENT ALTERNATIVE
PROPELLANT BURNING GROUND FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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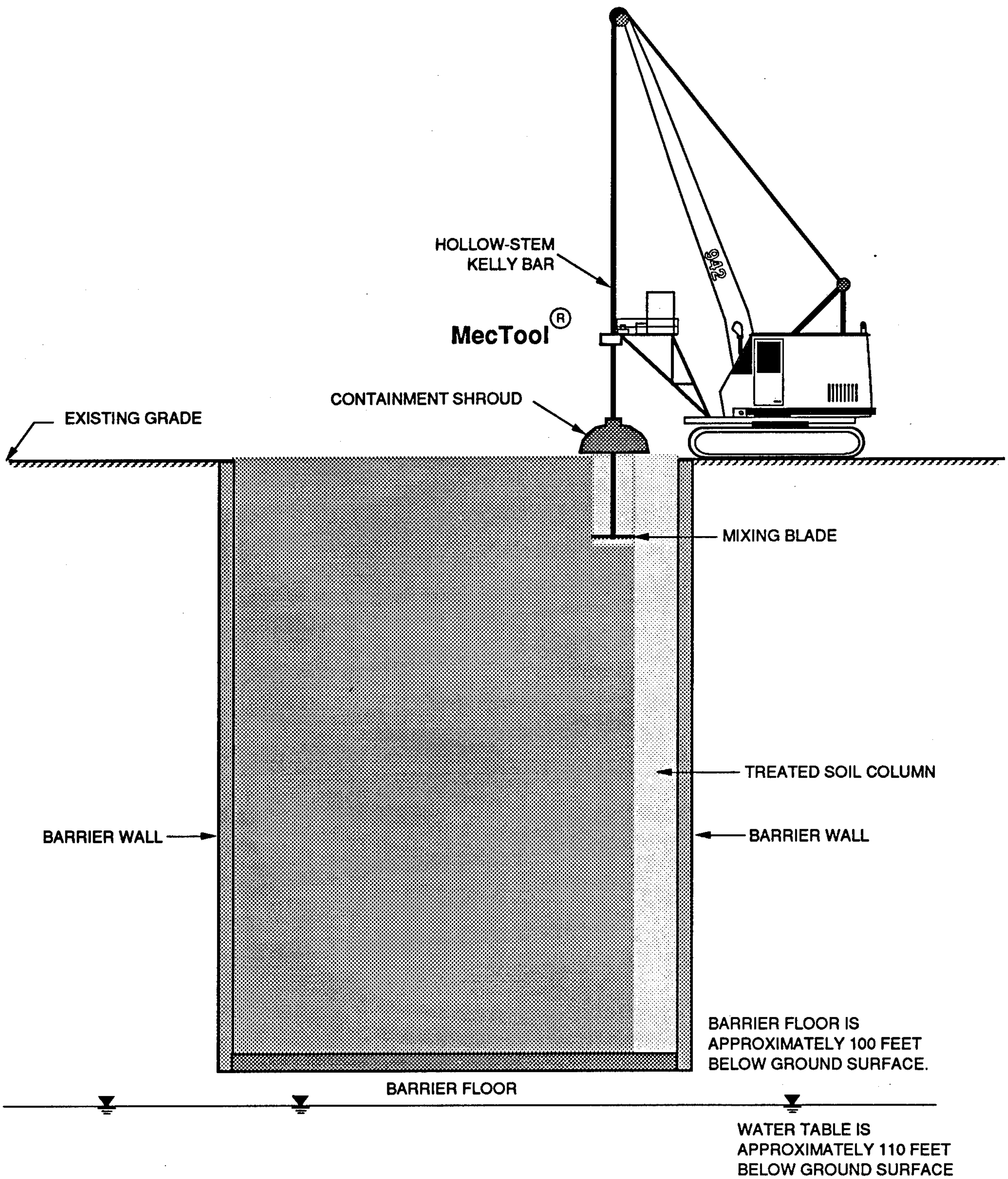
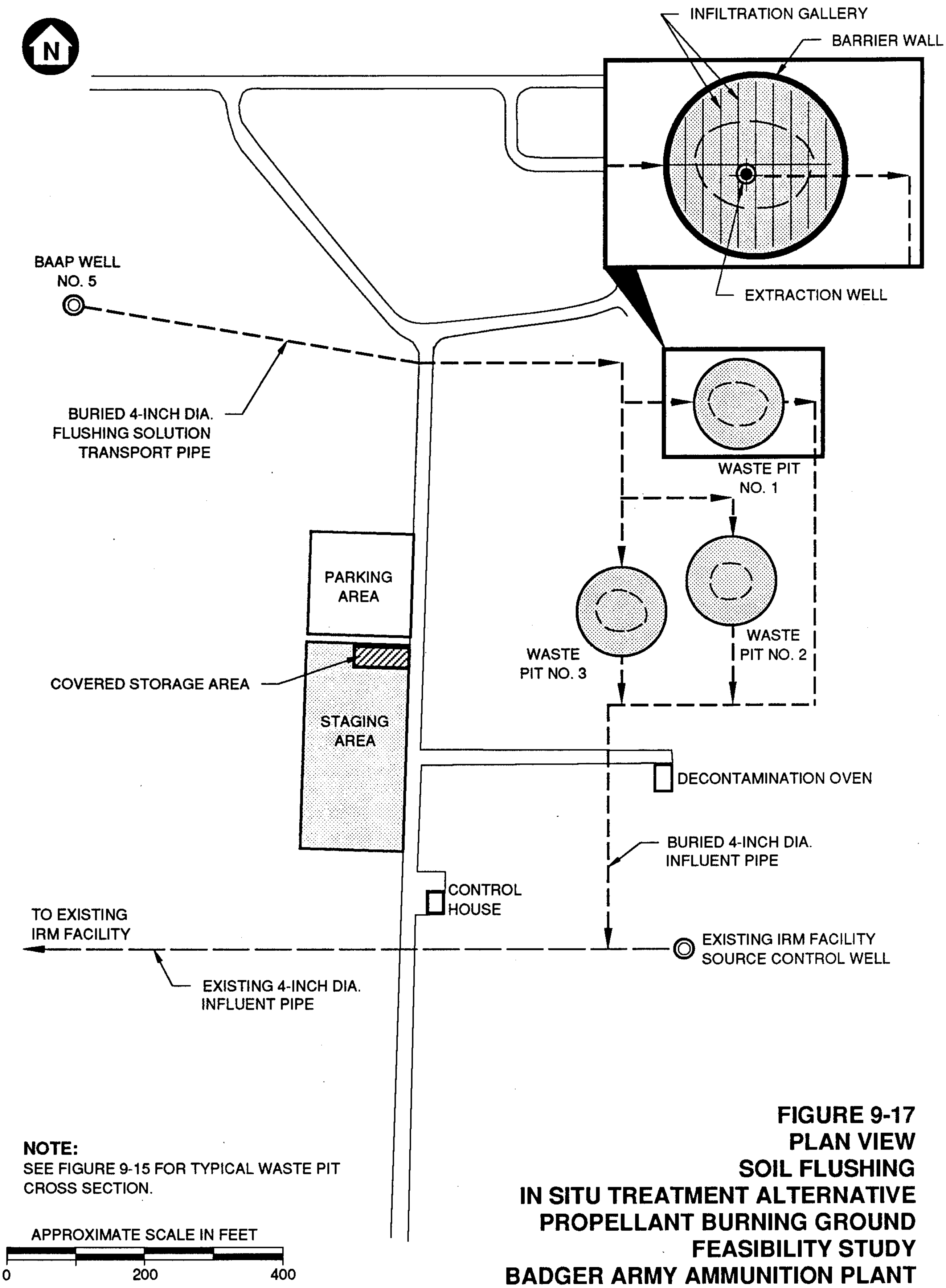


FIGURE 9-16
TYPICAL CROSS SECTION-CHEMICAL-BIOLOGICAL IN SITU TREATMENT ALTERNATIVE PROPELLANT BURNING GROUND FEASIBILITY STUDY BADGER ARMY AMMUNITION PLANT

NOT TO SCALE

ABB Environmental Services, Inc.

9407035D(m)

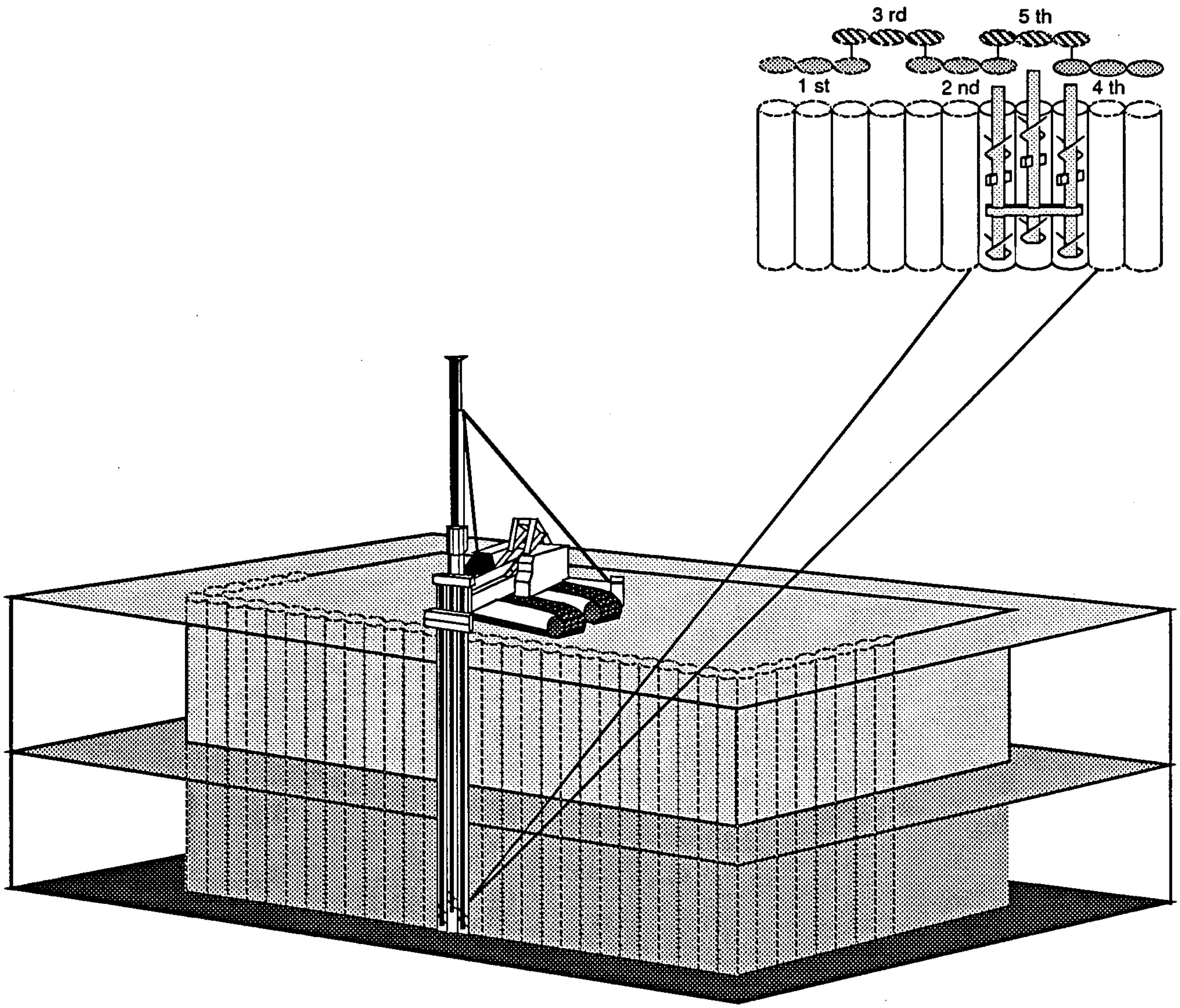


Source: Modified from Tsai, et.al., 1988.

FIGURE 9-17
PLAN VIEW
SOIL FLUSHING
IN SITU TREATMENT ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407035D(e)3



TECHNICAL DATA (TYPICAL VALUES)

Wall Thickness: 20" to 36" by design
Maximum Wall Depth: Greater than 200 feet
Permeability (K): Approaching 10^{-8} cm/sec
Strength: 50 to 3,000 psi depending on subsurface conditions
Acceptable Soil Conditions: Clay to gravel and cobbles
Production Rate: 1,000 to 1,500 ft^2 per 8-hour shift

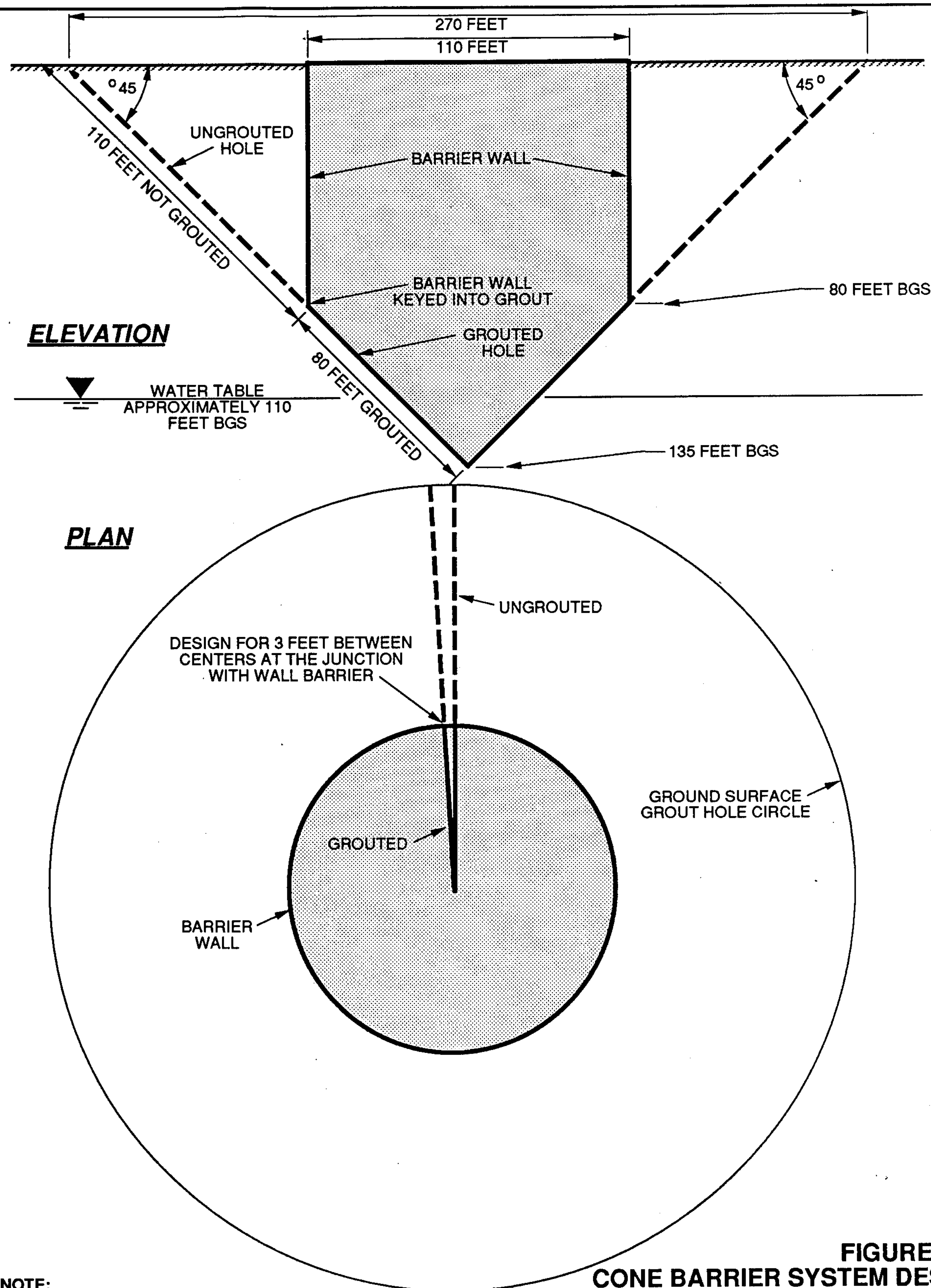
FIGURE 9-18
SLURRY WALL S.M.W. TECHNIQUES
IN SITU TREATMENT ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

Not To Scale

Source: S.M.W. Seiko, Inc.

ABB Environmental Services, Inc.

9407035D(h)



NOTE:
BGS = BELOW GROUND SURFACE

NOT TO SCALE

FIGURE 9-19
CONE BARRIER SYSTEM DESIGN
IN SITU TREATMENT ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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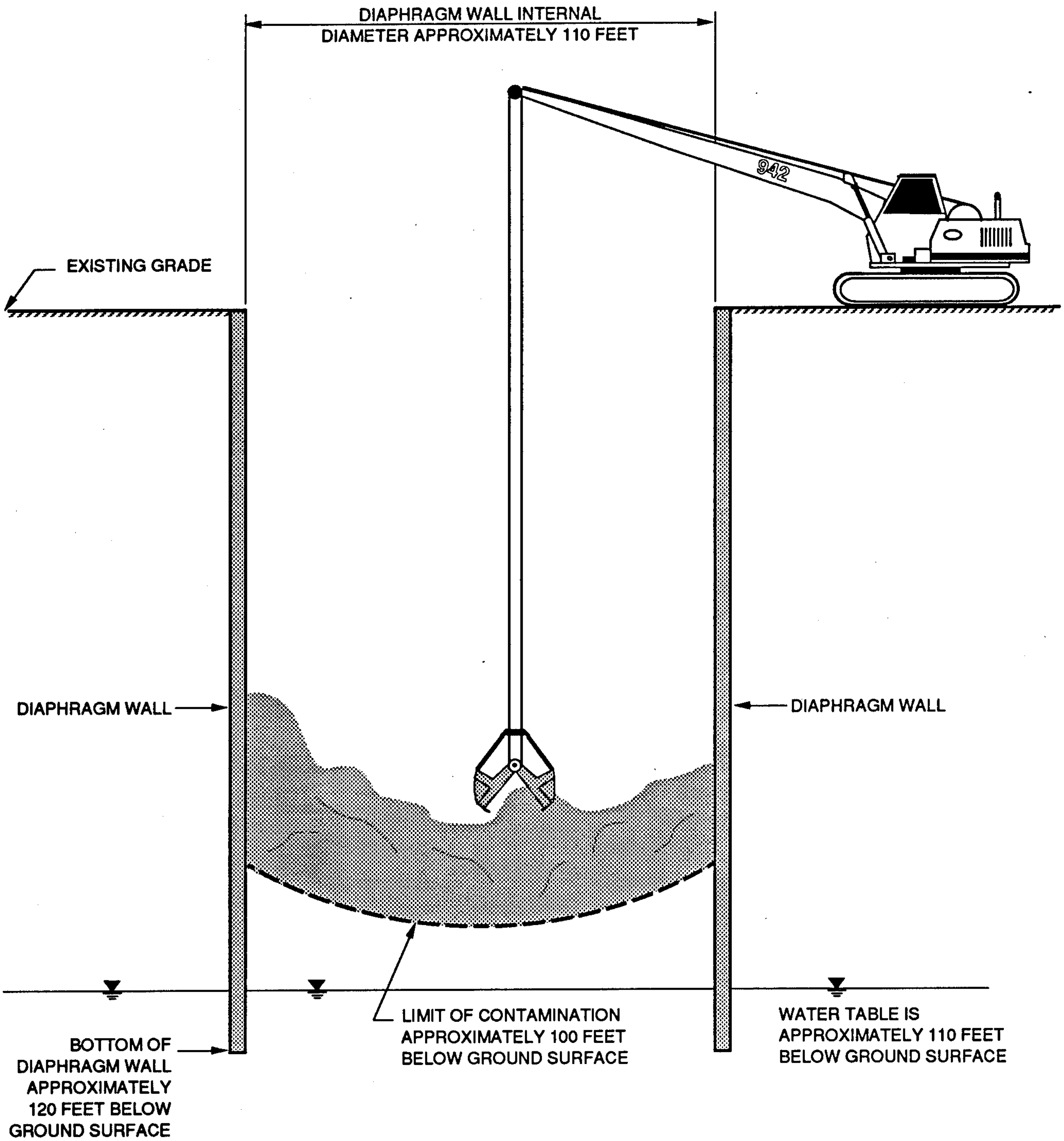

NOT TO SCALE

FIGURE 9-20
TYPICAL CROSS SECTION
ON-SITE INCINERATION ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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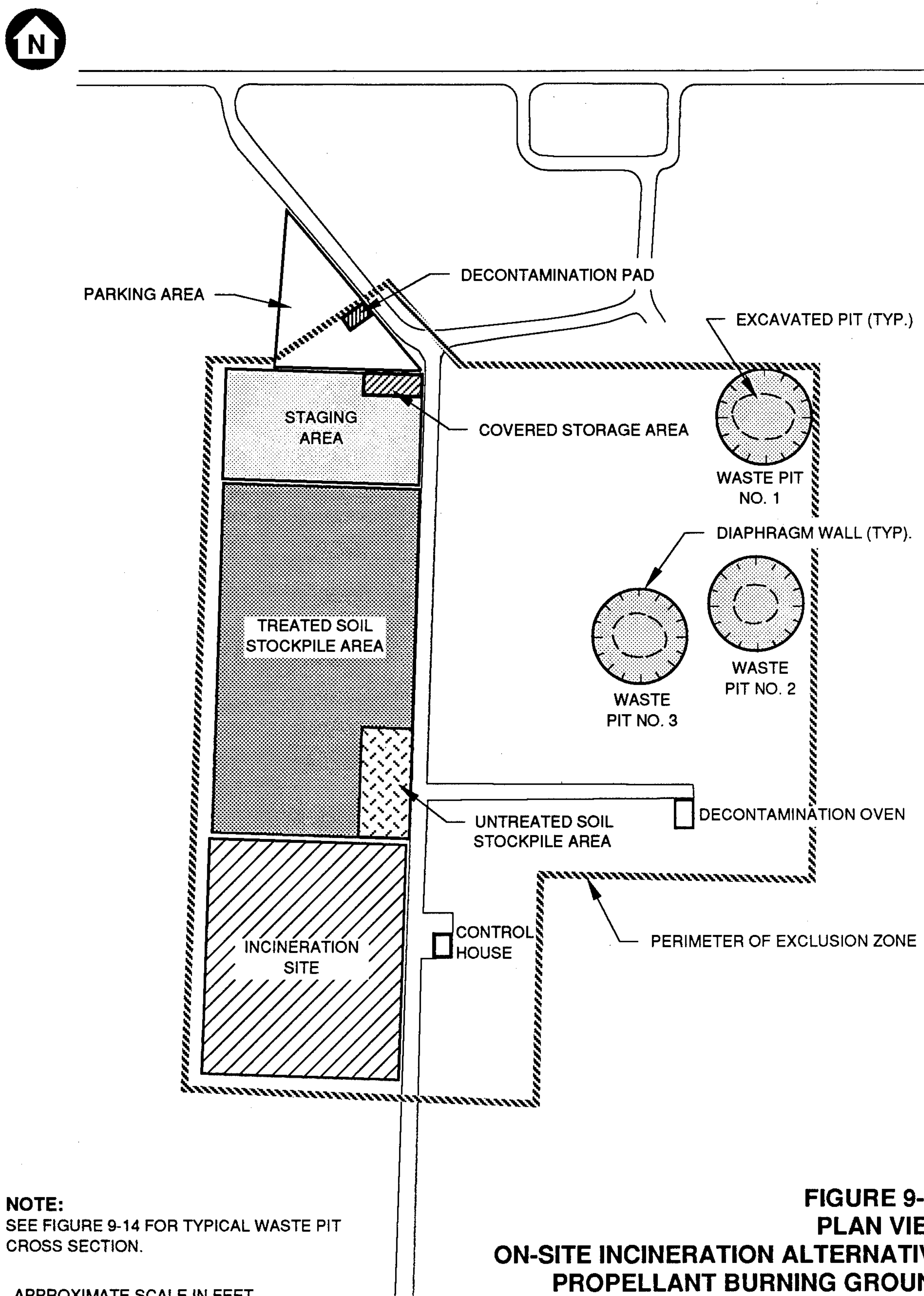

NOTE:
SEE FIGURE 9-14 FOR TYPICAL WASTE PIT CROSS SECTION.

APPROXIMATE SCALE IN FEET
0 200 400

Source: Modified from Tsai, et.al., 1988.

FIGURE 9-21
PLAN VIEW
ON-SITE INCINERATION ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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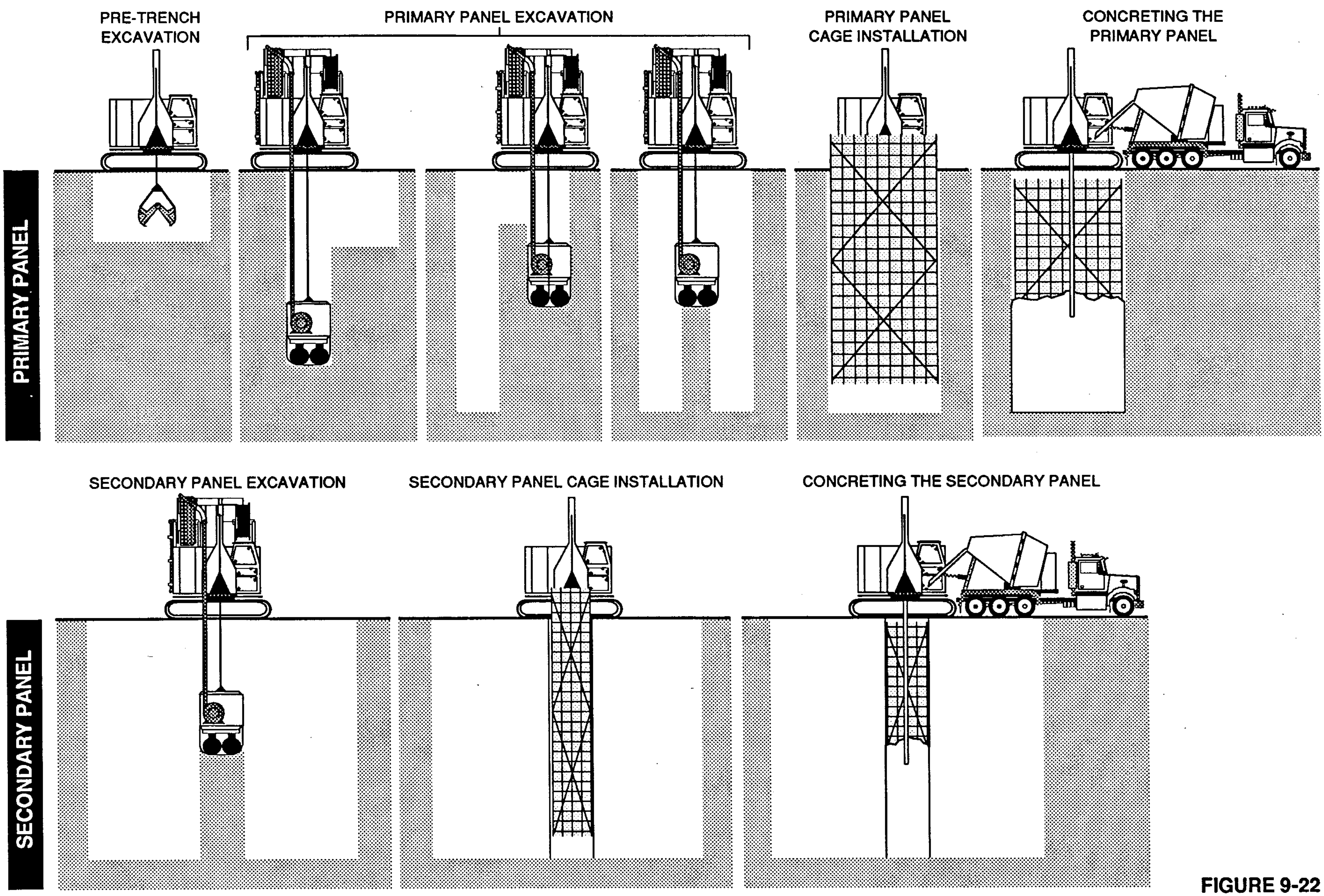


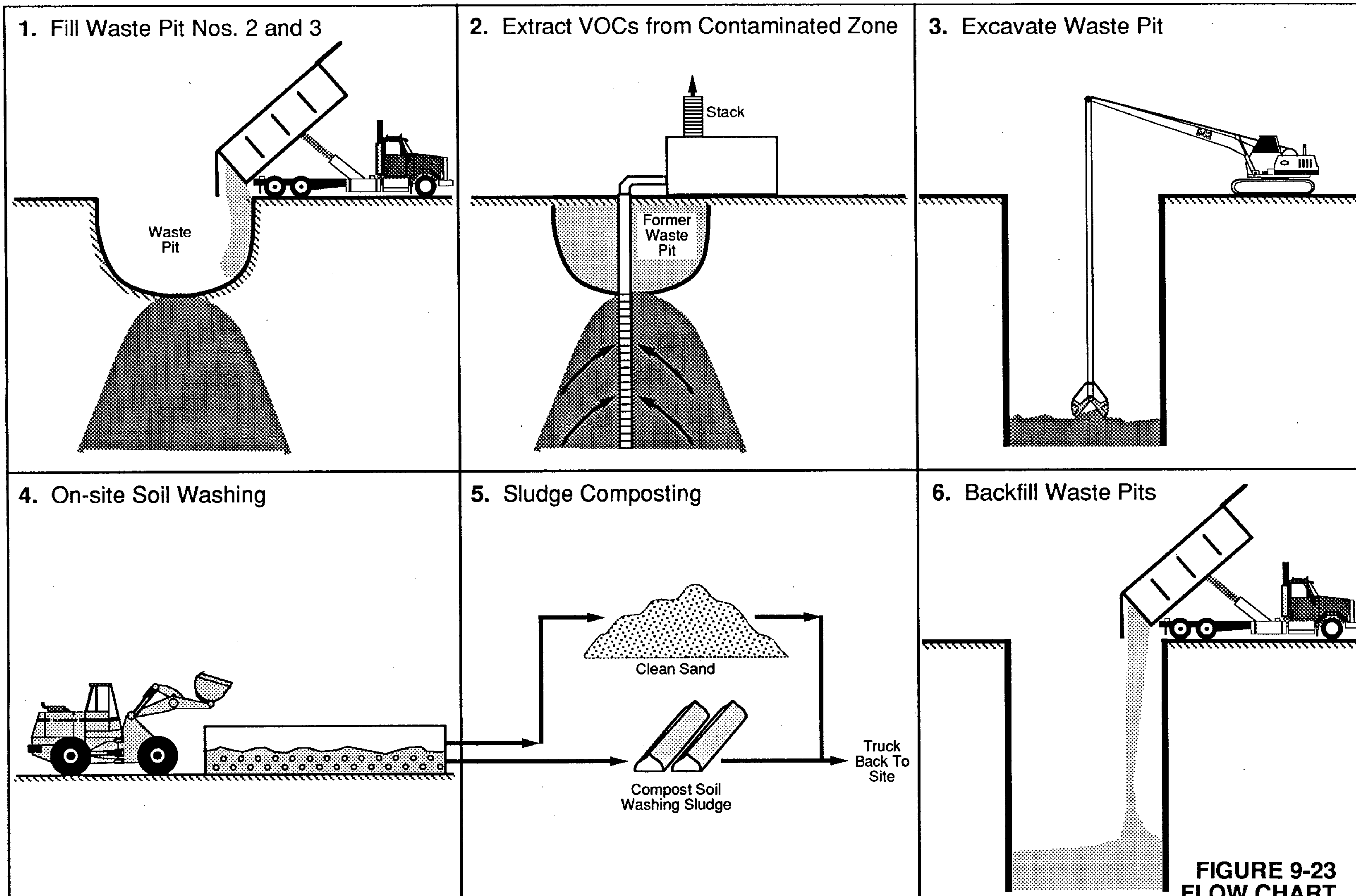
NOT TO SCALE

SOURCE: Nicholson Construction of America.

FIGURE 9-22
DIAPHRAGM WALL CONSTRUCTION
ON-SITE INCINERATION ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407035D(g)

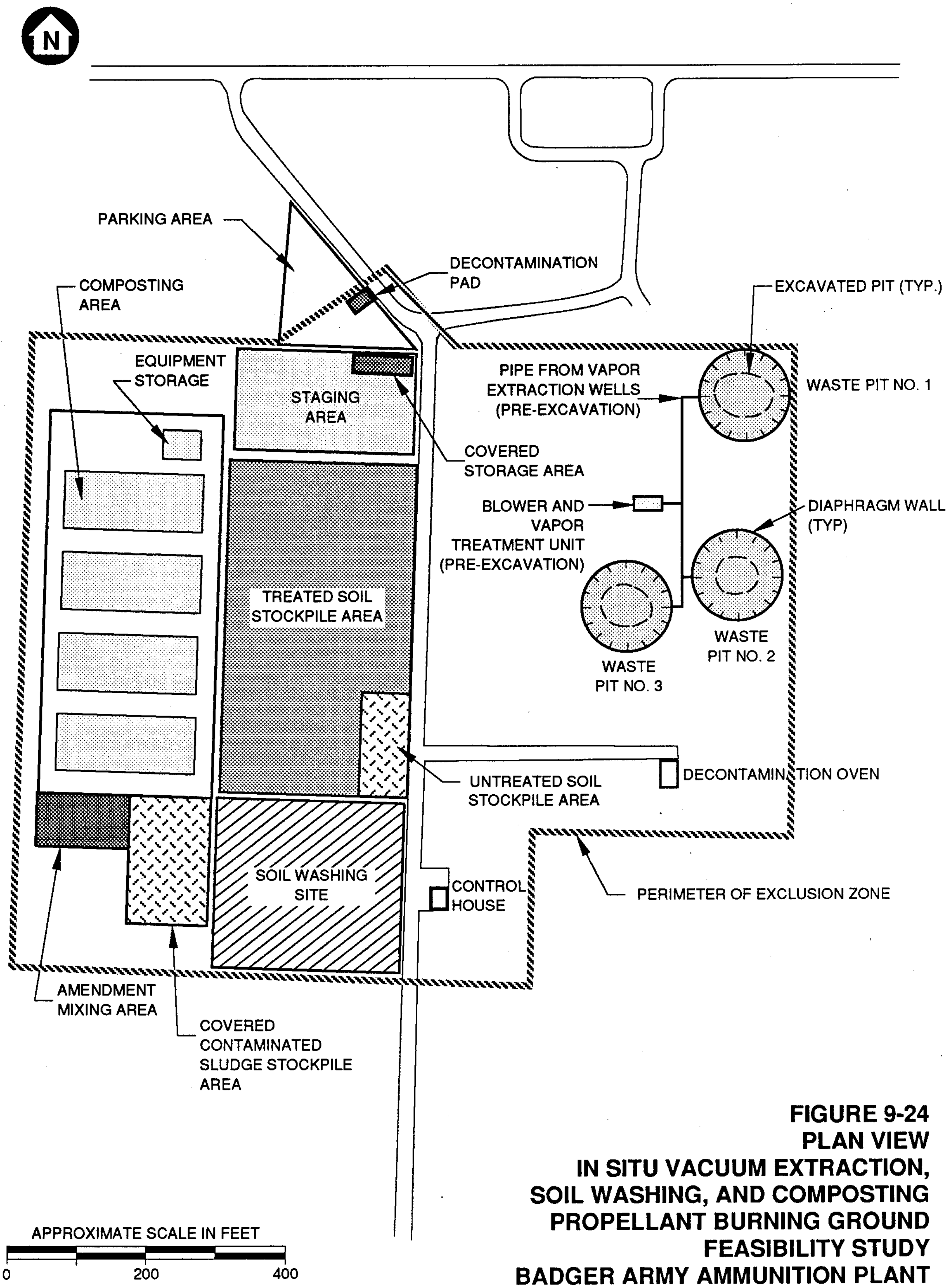


NOT TO SCALE

FIGURE 9-23
FLOW CHART
IN SITU VACUUM EXTRACTION, SOIL WASHING, AND COMPOSTING
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

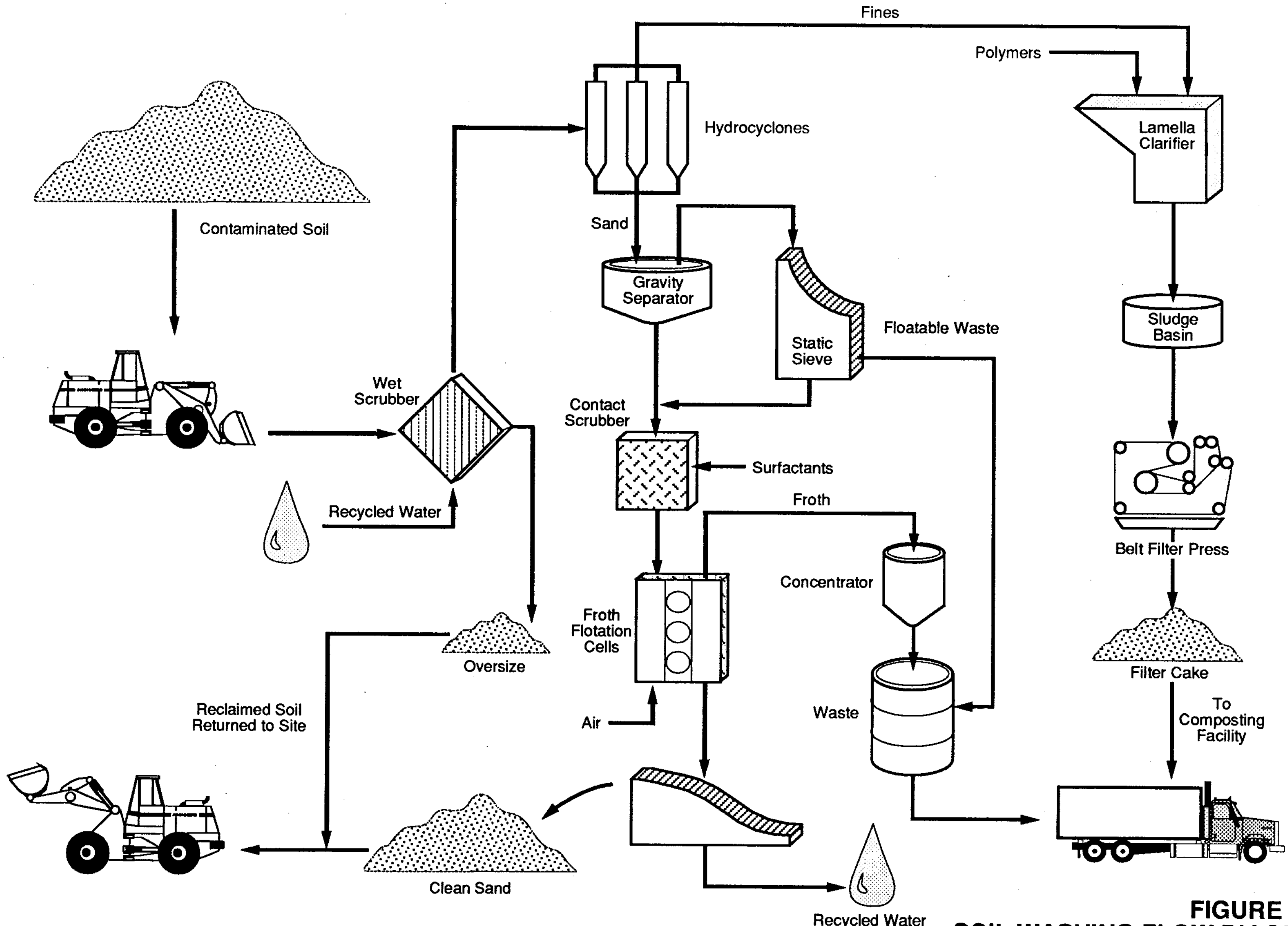
9407035D(k)



Source: Modified from Tsai, et.al., 1988.

FIGURE 9-24
PLAN VIEW
IN SITU VACUUM EXTRACTION, SOIL WASHING, AND COMPOSTING
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

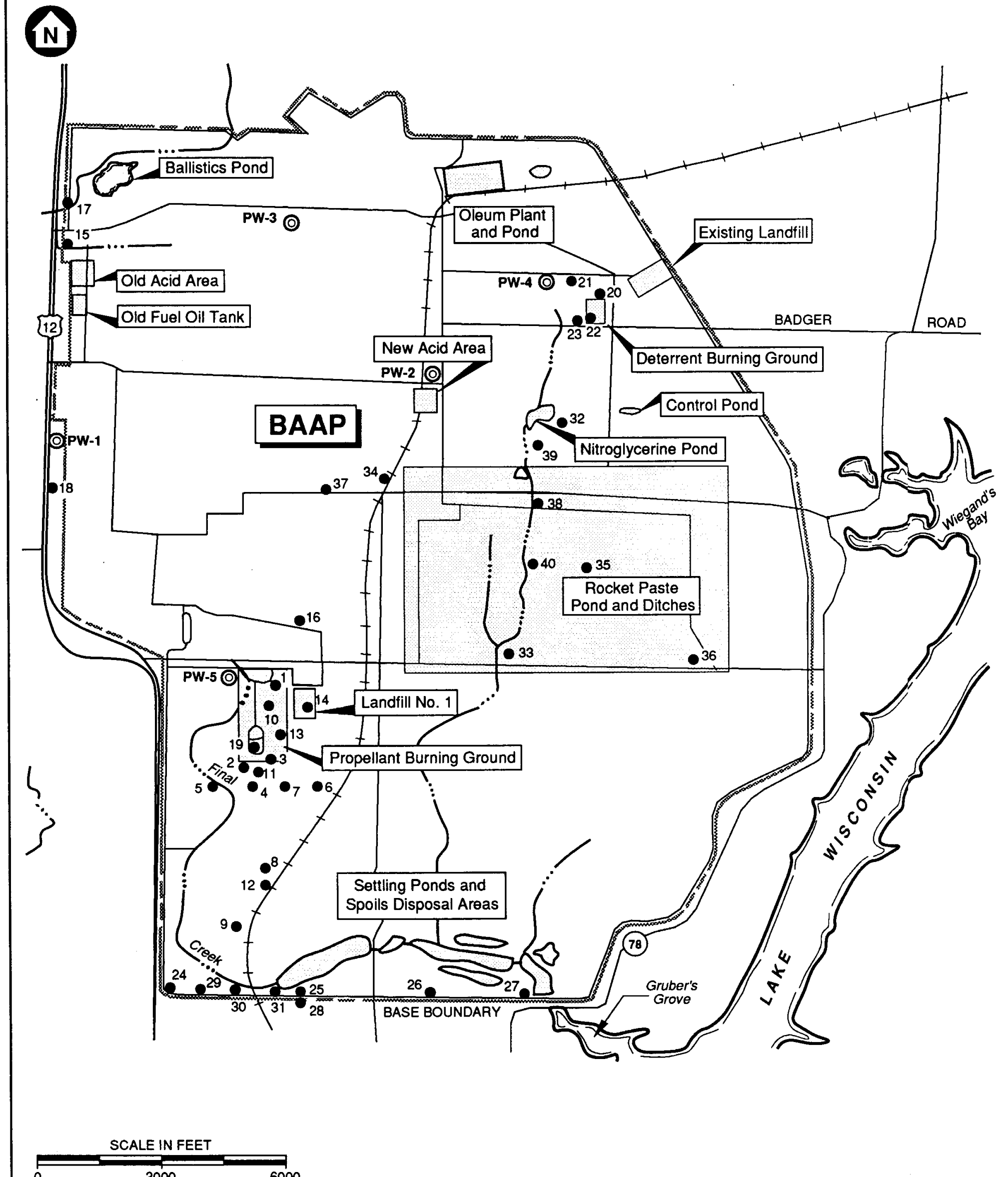


SOURCE:
GERAGHTY & MILLER, INC., AND HEIDEMIJ
RESTSTOFFENDIENSTEN BV. 1992

FIGURE 9-25
SOIL WASHING FLOW DIAGRAM
IN SITU VACUUM EXTRACTION, SOIL WASHING, AND COMPOSTING
PROPELLENT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

9407035D(b) 2

ABB Environmental Services, Inc.



PROPELLANT BURNING GROUND			
MAP CODE	WELL NUMBER	MAP CODE	WELL NUMBER
1	PBN-8201A,B,C	10	PBN-8202A,B,C
2	PBN-8203A,B,C	11	PBN-8204A,B,C
3	PBN-8205A,B,C	12	PBM-8506
4	PBN-8501A		PBN-9106C,D
	PBN-8901B,C,D	13	PBN-8910A,B,C,D
5	PBN-8503A	14	LON-8902A,B
	PBN-8903C,B		LON-8903A,B
6	PBM-8906	15	BGM-9102
7	PBN-8902B,C	16	LOM-9102
	PBN-8502A	17	BGM-9101
8	PBN-8904B,C	18	BGM-9103
	PBN-8504A	19	PBM-8204
9	PBN-8912A,B		

DETERRENT BURNING GROUND		ROCKET PASTE AREA/ NITROGLYCERINE POND	
MAP CODE	WELL NUMBER	MAP CODE	WELL NUMBER
20	DBM-8202	32	S1124
21	DBN-8904A,B	33	S1118
22	DBN-8201B,C	34	S1150
	S1122	35	RPM-8901
23	DBM-8905	36	RPM-9101
		37	S1125
		38	S1119
		39	NPM-8901
		40	RPM-8902

SETTLING PONDS/SPOILS DISPOSAL AREA			
MAP CODE	WELL NUMBER	MAP CODE	WELL NUMBER
24	S1101	28	S1152A,B
	S1133	29	SPN-8902A,B,C
	SPN-8901C		SPN-9102
25	S1102	30	SPN-9103D
	S1103		SPN-8903B,C
	S1149		S1147
26	S1104	31	S1148
	S1105		SPN-9104D
	S1106		SPN-8904B,C
27	S1107		
	S1108		
	SPN-8905A,B		

LEGEND

- BASE BOUNDARY
- 1 ● EXISTING MONITORING WELL LOCATION
- PW-1 ◎ PRODUCTION WELL LOCATION

NOTE:
GROUNDWATER MONITORING WELL LOCATIONS ARE FROM "MODIFICATION OF CONDITIONAL PLAN APPROVAL OF IN-FIELD CONDITIONS REPORT DATED SEPTEMBER 14, 1987" (WDNR, 1992).

FIGURE 9-26
GROUNDWATER MONITORING WELL LOCATIONS FOR MINIMAL ACTION ALTERNATIVES
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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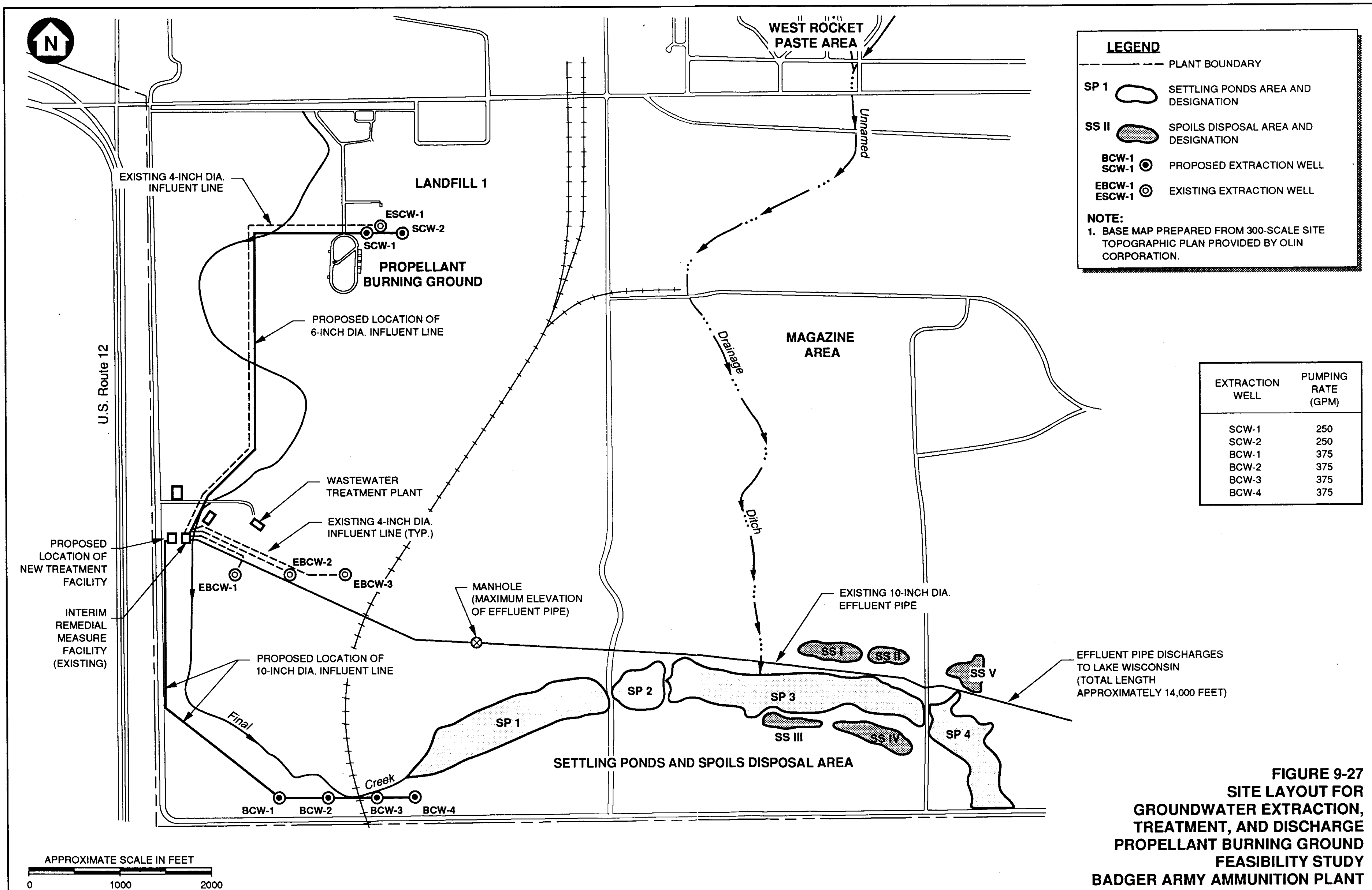


EXTRACTION WELL	PUMPING RATE (GPM)
SCW-1	250
SCW-2	250
BCW-1	375
BCW-2	375
BCW-3	375
BCW-4	375

FIGURE 9-27
SITE LAYOUT FOR GROUNDWATER EXTRACTION, TREATMENT, AND DISCHARGE
PROPELLANT BURNING GROUND FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407035D(y)123

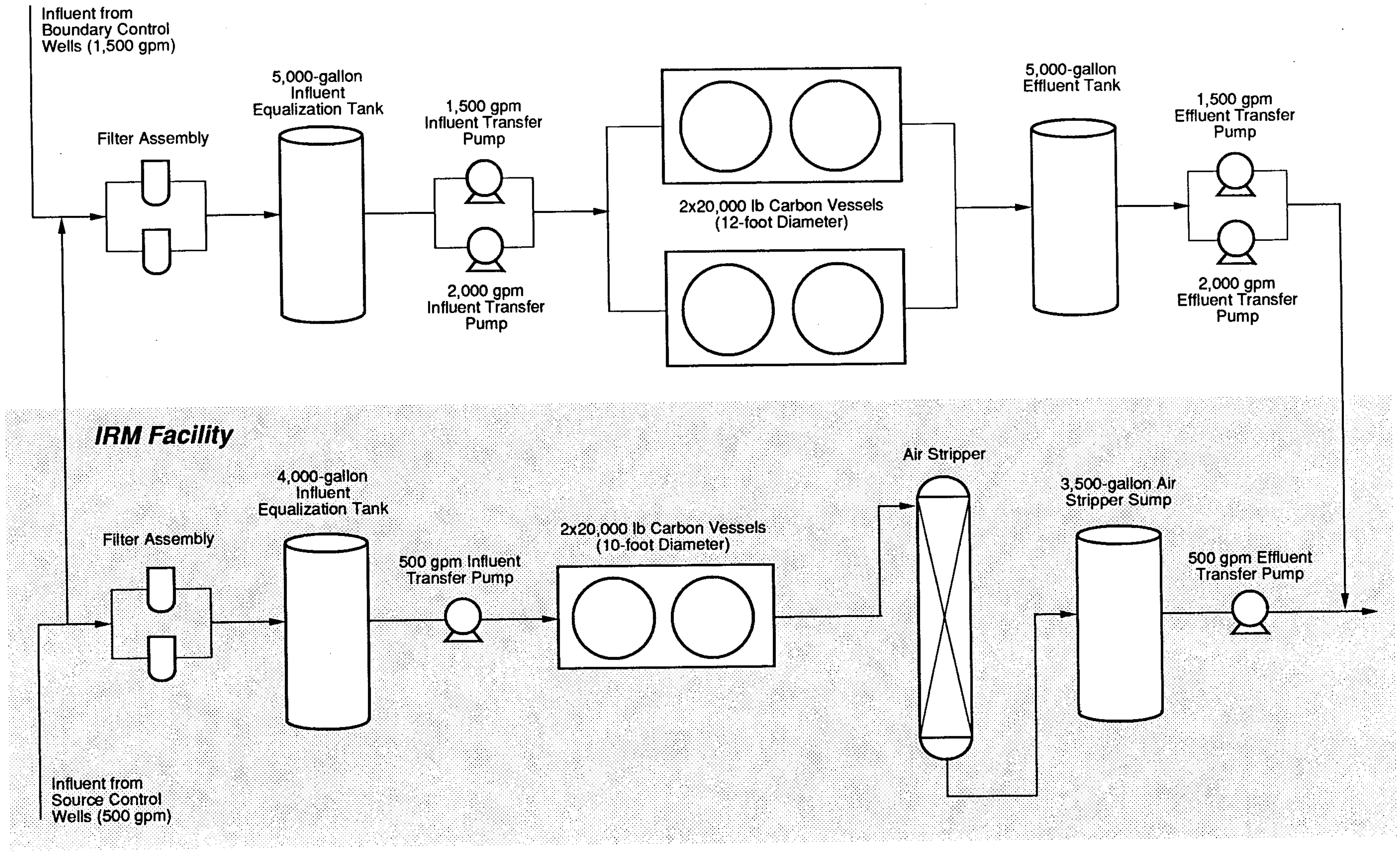


FIGURE 9-28
FLOW DIAGRAM
IRM AND CARBON ADSORPTION ALTERNATIVE
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407035D(t)

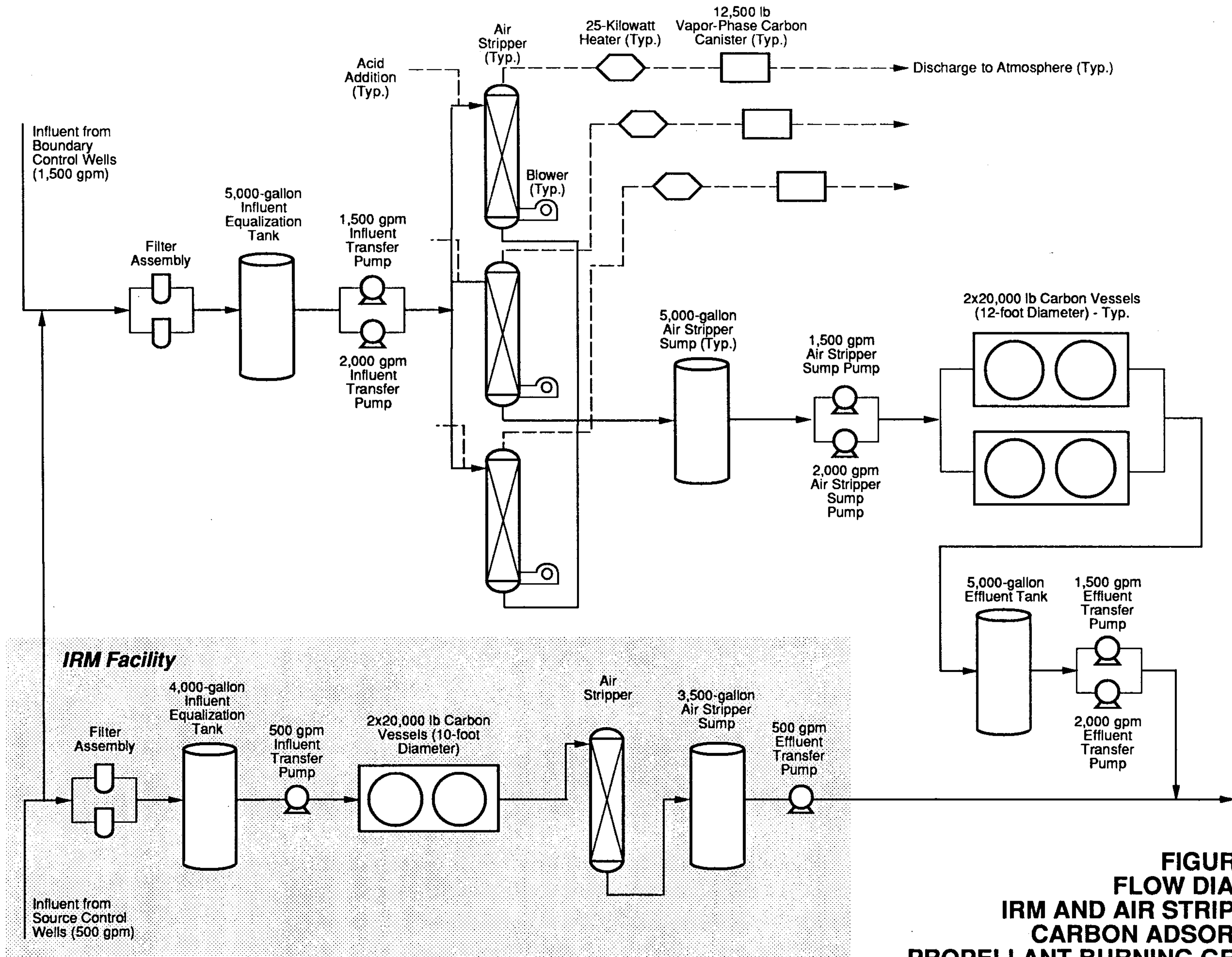
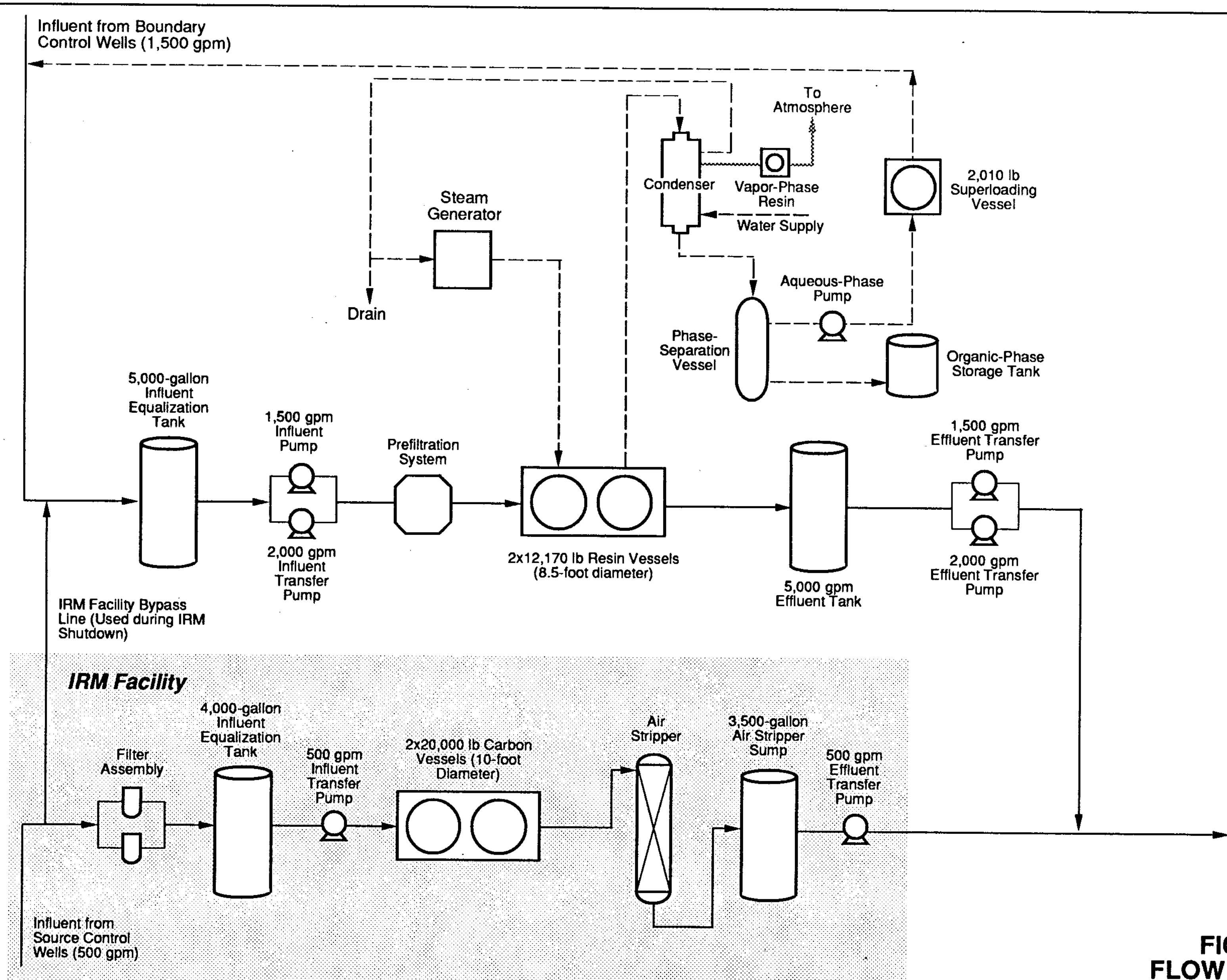


FIGURE 9-29
FLOW DIAGRAM
IRM AND AIR STRIPPING - CARBON ADSORPTION
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407035D(u)

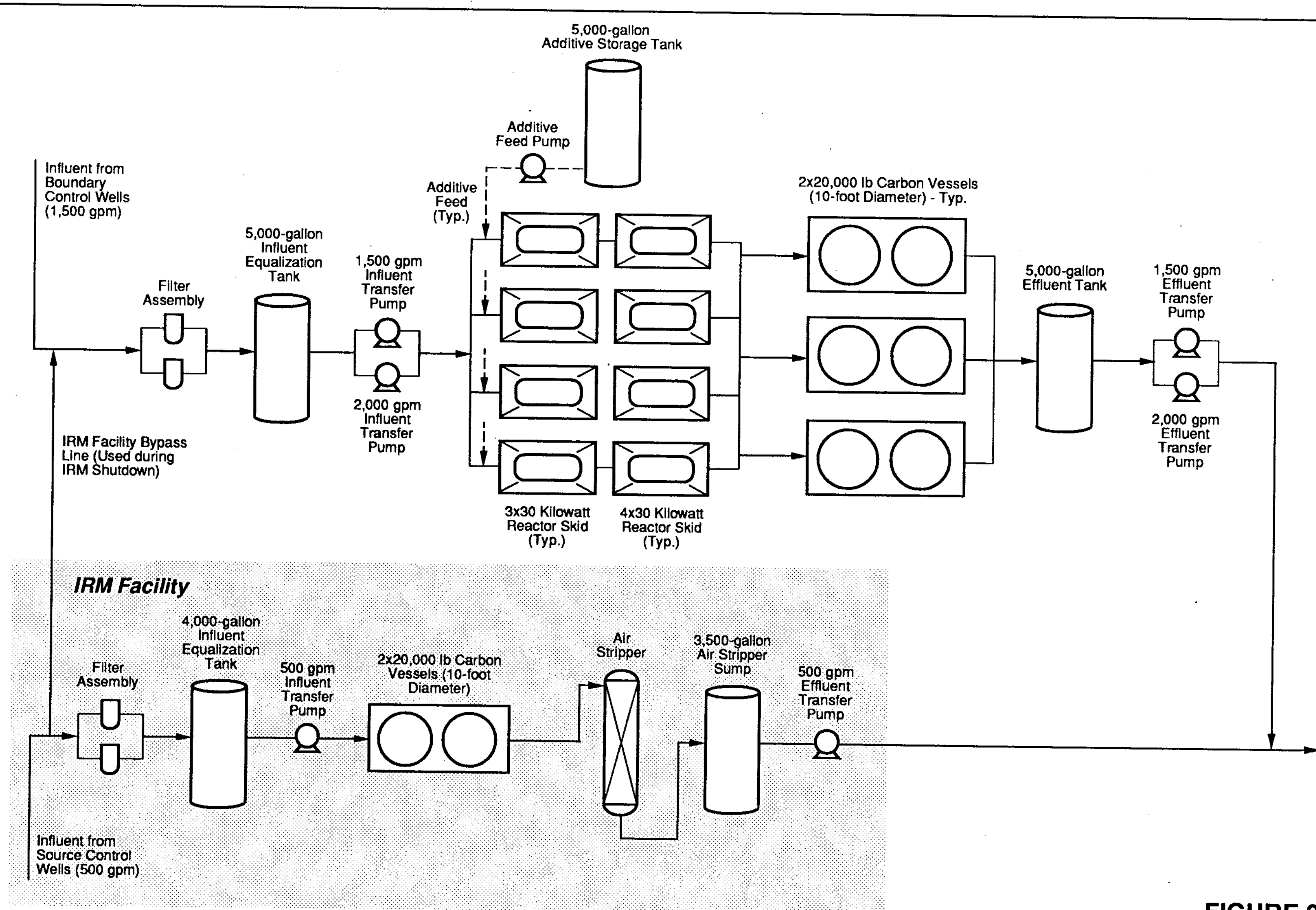


SOURCE: ROHM AND HAAS COMPANY.

FIGURE 9-30
FLOW DIAGRAM
IRM AND RESIN ADSORPTION
PROPELLANT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407035D(w)



SOURCE: SOLARCHEM ENVIRONMENTAL SYSTEMS.

FIGURE 9-31
FLOW DIAGRAM
IRM AND UV REDUCTION - CARBON ADSORPTION ALTERNATIVE
PROPELLANT BURNING GROUND FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

9407035D(v)

ABB Environmental Services, Inc.

Table 10-1
Groundwater Monitoring Program
Deterrent Burning Ground Groundwater Alternative DBG-GW1

Feasibility Study
Badger Army Ammunition Plant

Groundwater Monitoring Locations
DBN 8904 A, B
DBN 8201 B, C
S 1122
DBM 8905
DBM-82-02[1]

Analytical Parameters and Monitoring Frequency	
Quarterly	**Annually**
pH	VOCs, SVOCs, and Metals (filtered)[2]
Specific Conductance	
Sulfate	
Nitrate Nitrogen	
Chromium (filtered)	

Notes:

1 Recommended additional monitoring well.
2 VOCs, SVOCs, and metals as described in Modification of Conditional Plan Approval of In-Field Conditions Report (WDNR, 1992).

TABLE 10-2
COST SUMMARY TABLE
ALTERNATIVE DBG-SB1: MINIMAL ACTION

FEASIBILITY STUDY
DETERRENT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST		
Institutional controls	$	10,000
TOTAL DIRECT COST	**$**	**10,000**
INDIRECT COST		
Health and Safety @ 5% of Total Direct Cost	$	0
Legal, Administration, Permitting @ 5% of Total Direct Cost		0
Engineering @ 10% of Total Direct Cost		0
Services During Construction @ 10% of Total Direct Cost		0
TOTAL INDIRECT COST	**$**	**0**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**10,000**
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	7,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$**	**108,000**
TOTAL COST FOR SB-1 MINIMAL ACTION	**$**	**118,000**

Table 10-3
Detailed Analysis - Alternative DBG-SB1
Deterrent Burning Ground Subsurface Soil

Feasibility Study
Badger Army Ammunition Plant

Evaluation Criteria	Alternative DBG-SB1 Minimal Action
Overall Protection of Human Health and the Environment	
Human Health Protection	Minimal action controls potential risk posed by the soils at the Deterrent Burning Ground. This alternative focuses on reducing contaminant exposure by restricting site access through the use of institutional controls.
Environmental Protection	There is no environmental risk associated with subsurface soils at the Deterrent Burning Ground.
Compliance with ARARs	
Chemical-specific	There are no promulgated chemical-specific ARARs for soil. The minimal action alternative would not meet RGs for Deterrent Burning Ground soils.
Location-specific	Location-specific ARARs do not apply to this alternative because no action would be taken.
Action-specific	General RCRA requirements pertaining to permitted Hazardous Waste TSD Units would be satisfied by the minimal action alternative. Federal OSHA requirements to protect worker health and safety would be followed during the site work. Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Under the minimal action alternative, contaminant levels in the soil are not expected to decrease significantly over time.
Adequacy and Reliability of Controls	If managed properly, institutional controls effectively limit public access and use of the site.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Minimal action does not employ removal or treatment processes to address soil contamination at the Deterrent Burning Ground.
Amount Destroyed or Treated	There would be no contaminants destroyed or treated.

continued

TABLE 10-3
DETAILED ANALYSIS - ALTERNATIVE DBG-SB1
DETERRENT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB1 MINIMAL ACTION
Degree of Expected Reductions of Toxicity, Mobility, and Volume	Minimal action does not employ removal or treatment processes to address soil contamination at the Deterrent Burning Ground. Therefore, no reduction in toxicity, mobility, or volume of contaminated soils would be achieved.
Degree to Which Treatment is Irreversible	Not Applicable. No treatment is employed with this alternative.
Type and Quantity of Residuals Remaining After Treatment	Not Applicable. No treatment is employed with this alternative.
Short-term Effectiveness	
Protection of Community During Remedial Action	Because this alternative provides only a minimal response action (i.e., zoning and deed restrictions), threats to the community are unlikely to be encountered during implementation.
Protection of Workers During Remedial Action	This alternative provides only a minimal response action which does not require any construction. However site workers involved in the groundwater monitoring program should follow safe working practices.
Environmental Impacts	No impacts to the environment should be encountered during implementation.
Time Until Remedial Action Objectives Are Achieved	Unknown. Remedial action objectives may never be achieved with minimal action.
Implementability	
Ability to Construct and Operate the Technology	Not Applicable. No construction is involved with this alternative.
Reliability of the Technology	Not Applicable. No technology is used with this alternative.
Ease of Undertaking Additional Remedial Actions, if Necessary	Minimal action would not limit or interfere with the ability to perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	The proposed groundwater monitoring program would adequately monitor contaminant migration.
Ability to Obtain Approvals and Coordinate with Other Agencies	Coordination with appropriate Army officials, WDNR, and the City of Baraboo would be required if these controls are applied. Coordination with Sauk County would be required to implement and maintain a public education program.

continued

TABLE 10-3
DETAILED ANALYSIS - ALTERNATIVE DBG-SB1
DETERRENT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB1 MINIMAL ACTION
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Not Applicable.
Availability of Necessary Equipment and Specialists	Local contractors are readily available to conduct educational programs.
Availability of Technology	Not Applicable. No technology used.
Costs	
Capital Cost	$10,000 for institutional controls.
Present Worth of Operation and Maintenance Cost	$108,000
Net Present Worth Cost	$118,000

TABLE 10-4
COST SUMMARY TABLE
ALTERNATIVE DBG-SB2: CAPPING

FEASIBILITY STUDY
DETERRENT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM	TOTAL COST
DIRECT COST OF CAPPING	
Site preparation and mob/demob	$ 157,000
Contaminated soil delineation	80,000
Cap construction	163,000
Institutional controls	10,000
TOTAL DIRECT COST OF CAPPING	**$ 410,000**
INDIRECT COST OF CAPPING	
Health and Safety @ 5% of Total Direct Cost	$ 21,000
Legal, Administration, Permitting @ 5% of Total Direct Cost	21,000
Engineering @ 10% of Total Direct Cost	41,000
Services During Construction @ 10% of Total Direct Cost	41,000
TOTAL INDIRECT COST OF CAPPING	**$ 124,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$ 534,000
OPERATING AND MAINTENANCE COSTS	
Total Annual Operating and Maintenance Costs	$ 7,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$ 108,000**
TOTAL COST OF CAPPING	**$ 642,000**

TABLE 10-5
DETAILED ANALYSIS - ALTERNATIVE DBG-SB2
DETERRENT BURNING GROUND SUBSURFACE SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB2 CAPPING
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objective for protection of human health. The RCRA cap and institutional controls would reduce the potential for human exposure to subsurface soil with contaminant concentrations greater than remediation goals.
Environmental Protection	No ecological risk associated with contaminated subsurface soil. The RCRA caps would reduce leachate generation such that groundwater is protected.
Compliance with ARARs	
Chemical-specific	Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Because soil contaminants would not be removed or destroyed, this alternative would not comply with pathway-specific numeric standards derived from the proposed Chapter NR 720. However, the RCRA caps used in this alternative could be designed to achieve a performance standard which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of human health and groundwater.
Location-specific	RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR - Part 264) may apply. If applicable, a program which incorporates the standards would be implemented. RCRA, Releases from Solid Waste Management Units (Subpart F, 264.90-264.109) may apply for post-closure monitoring of the site. This alternative would include continued groundwater monitoring at the Deterrent Burning Ground. Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.

continued

TABLE 10-5
DETAILED ANALYSIS - ALTERNATIVE DBG-SB2
DETERRENT BURNING GROUND SUBSURFACE SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB2 CAPPING
Action-specific	Federal OSHA requirements to protect worker health and safety would be followed during the site work. Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be considered prior to implementation of this alternative.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Provided the RCRA caps remain intact, residual risk to human receptors and the threat of groundwater contamination would be negligible. Post-remediation invasive activities through the caps could result in significant exposure events and cause leachate generation and associated degradation of groundwater quality.
Adequacy and Reliability of Controls	Institutional controls would protect the caps from invasive activities and restrict residential or public use of the site. Visual inspections would be conducted annually to ensure the integrity of the caps. Long-term groundwater monitoring would detect soil contaminants leaching into groundwater.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	No treatment of contaminated soils would occur.
Amount Destroyed or Treated	No treatment of contaminated soils would occur.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	No reduction in the toxicity, mobility, or volume of contaminants. However, natural mobilizing influences such as infiltration of precipitation and associated leachate generation would be reduced.
Degree to Which Treatment is Irreversible	No treatment of contaminated soils would occur.
Type and Quantity of Residuals Remaining After Treatment	No treatment of contaminated soils would occur.

continued

TABLE 10-5
DETAILED ANALYSIS - ALTERNATIVE DBG-SB2
DETERRENT BURNING GROUND SUBSURFACE SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB2 CAPPING
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation. There are no residences close enough to the site to be affected by noise or dust.
Protection of Workers During Remedial Action	With the use of dust suppression techniques and adherence to general health and safety practices, there would be minimal risk to workers.
Environmental Impacts	The burning pits at the Deterrent Burning Ground are not considered critical wildlife habitats and the impact to the ecological community is expected to be minor.
Time Until Remedial Action Objectives Are Achieved	An estimated two to three months would be required to achieve the remedial action objectives.
Implementability	
Ability to Construct and Operate the Technology	RCRA cap construction can be accomplished using standard construction procedures and conventional earth-moving equipment. Cap repairs would be easily implemented.
Reliability of the Technology	Capping is a proven technology for reducing leachate generation and is generally the prescribed method for landfill closure.
Ease of Undertaking Additional Remedial Actions, if Necessary	Capping would increase the scope of any future removal actions.
Ability to Monitor Effectiveness of Remedy	Annual visual inspections and groundwater monitoring would be sufficient for monitoring cap effectiveness.
Ability to Obtain Approvals and Coordinate with Other Agencies	The integrity of the remedial design would have to be demonstrated to federal and state regulators. Other special permits (e.g., wetland permit) would not be necessary.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Contaminated soil would not be transported off site.
Availability of Necessary Equipment and Specialists	Obtaining sufficient quantities of clay, sand, common borrow soil, and topsoil in the immediate vicinity of BAAP should not be difficult. Materials may be available within 30 miles of BAAP.

continued

TABLE 10-5
DETAILED ANALYSIS - ALTERNATIVE DBG-SB2
DETERRENT BURNING GROUND SUBSURFACE SOILS

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB2 CAPPING
Availability of Technology	A large excavation contracting company with experience in landfill construction/closure could provide the equipment and expertise for constructing the caps.
Costs	
Capital Cost	$534,000
Present Worth of Operation and Maintenance Cost	$108,000
Present Worth Cost	$642,000

TABLE 10-6
COST SUMMARY TABLE
ALTERNATIVE DBG-SB4: SOIL WASHING

FEASIBILITY STUDY
DETERRENT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST		
Treatability testing	$	30,000
Site Preparation and mob/demob		379,000
Contaminated soil delineation		130,000
Soil excavation		122,000
Soil washing		2,931,000
Backfill		165,000
TOTAL DIRECT COST	$	3,757,000
INDIRECT COST		
Health and Safety @ 5% of Total Direct Cost	$	188,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		188,000
Engineering @ 10% of Total Direct Cost		376,000
Services During Construction @ 10% of Total Direct Cost		376,000
TOTAL INDIRECT COST	$	1,128,000
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$	4,885,000
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	7,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	$	108,000
TOTAL COST FOR SB-4 SOIL WASHING	$	4,993,000

TABLE 10-7
DETAILED ANALYSIS - ALTERNATIVE DBG-SB4
DETERRENT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB4 SOIL WASHING
Overall Protection of Human Health and the Environment	
Human Health Protection	Under the soil washing alternative, contaminated soils are removed and treated. Therefore, this alternative achieves remedial action objectives for subsurface soils at the Deterrent Burning Ground.
Environmental Protection	There is no environmental risk associated with subsurface soils at the Deterrent Burning Ground.
Compliance with ARARs	
Chemical-specific	There are no promulgated chemical-specific ARARs for soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soils remediation. The soil washing alternative would meet RGs for Deterrent Burning Ground soils.
Location-specific	There are no location-specific ARARs.
Action-specific	RCRA requirements pertaining to permitted Hazardous Waste TSD units would be addressed in the soil washing alternative. Any RCRA permits required would be obtained. DOT and RCRA requirements pertaining to transportation of hazardous waste would by addressed by this alternative. General WDNR and NAAQS requirements pertaining to the control of air emissions would be addressed by this alternative. CAA-NAAQS, RCRA and WDNR requirements pertaining to excavation would be addressed by this alternative. General RCRA requirements pertaining to land disposal would be addressed in the soil washing alternative. Federal OSHA requirements to protect worker health and safety would be followed during any site work. Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.

continued

TABLE 10-7
DETAILED ANALYSIS - ALTERNATIVE DBG-SB4
DETERRENT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB4 SOIL WASHING
	RCRA, Land Disposal Restrictions (LDRs); (40 CFR Part 268) may apply to C6H6 waste disposed of in the waste pits. The C6H6 waste has been identified as a listed hazardous waste from non-specific sources (i.e., F005), per 40 CFR Part 261.31. As such, C6H6-contaminated soil may be subject to LDRs and, if excavated, must be treated so that it no longer "contains" C6H6 or treated to a concentration level prior to disposal in a RCRA Subtitle C permitted facility. In addition, 24DNT-contaminated soil in the waste pits would be characteristically hazardous if it exceeds the TCLP threshold for 24DNT waste. If classified as hazardous, and 24DNT-contaminated soil is excavated, the "characteristic" would have to be removed from the soil prior to disposal or placement on site.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Under the soil washing alternative, contaminated soils are excavated and treated on-site. Treatment residuals will be transported off-site or to the PBG. Only soils meeting RGs will be put back in the hole. Therefore, residual risk to construction workers doing intrusive work would be eliminated after treatment and there would no longer be leaching potential.
Adequacy and Reliability of Controls	Soil washing would permanently reduce contaminant concentrations to below RGs. The potential for exposure and leaching would be eliminated.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Soil washing would be used to reduce concentrations of 24DNT in subsurface soils to below those considered protective of human health.
Amount Destroyed or Treated	It is estimated that 5,700 cubic yards of contaminated soil would be excavated and treated. Maximum 24DNT concentration is 37,000 mg/kg. Concentrations will be reduced to below 4.29 mg/kg. Contaminants are more tightly bound to the fine-grained soil fraction which is converted to a sludge, producing approximately 500 cubic yards of dry solids filter cake to be disposed of off-site or sent to the Propellant Burning Ground for composting.

continued

TABLE 10-7
DETAILED ANALYSIS - ALTERNATIVE DBG-SB4
DETERRENT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB4 SOIL WASHING
Degree of Expected Reductions of Toxicity, Mobility, and Volume	Toxicity of the contaminant would not be reduced, but the contaminated residuals would be removed from the site. The residuals would be treated off-site, therefore, the mobility of the contaminant through the soil matrix would be reduced. The volume of contaminated soil would be reduced from 5,700 cubic yards to 500 cubic yards of filter cake.
Degree to Which Treatment is Irreversible	Soil washing treatment separates the contaminant from the soil matrix, therefore treatment is permanent.
Type and Quantity of Residuals Remaining After Treatment	Filter cake contaminated with 24DNT would be a residual of the soil washing process. The filter cake would be treated in an off-site incinerator. The make-up water used in the soil washing process is recycled throughout treatment, but requires disposal after treatment.
Short-term Effectiveness	
Protection of Community During Remedial Action	There would be no threats to the community during remedial action.
Protection of Workers During Remedial Action	Construction workers excavating soil are at risk of soil ingestion. Workers would follow safe working practices.
Environmental Impacts	The soil washing treatment facility calls for containment and treatment of any run-off from the site. Therefore, no impacts to the environment should be encountered during implementation.
Time Until Remedial Action Objectives Are Achieved	Treatability tests are expected to take 8 to 10 weeks to conduct. Site preparation and mobilization, excavation of soils, and construction of the treatment facility is expected to take 2 to 3 months. Treatment of the contaminated soil is expected to be complete in 6 to 8 weeks. Disposal, backfilling of treated soils, and overall site cleanup could take an additional month.
Implementability	
Ability to Construct and Operate the Technology	Prior to implementing the technology, bench-scale and pilot-scale treatability tests to determine the feasibility of soil washing as well as to confirm process parameters. The availability of vendors to perform soil washing is limited. Construction and operation of the facility is done by the vendor.

continued

TABLE 10-7
DETAILED ANALYSIS - ALTERNATIVE DBG-SB4
DETERRENT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB4 SOIL WASHING
Reliability of the Technology	Unknown. Until bench-scale tests can be done on a representative sample, it is unclear whether soil washing is a feasible alternative.
Ease of Undertaking Additional Remedial Actions, if Necessary	Soil washing would not limit or interfere with the ability to perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	A mobile laboratory would be available on-site with a colorimetric spectrophotometer capable of analyzing for 24DNT in treated soils.
Ability to Obtain Approvals and Coordinate with Other Agencies	It is assumed that the agencies will work cooperatively with BAAP in obtaining the necessary permits.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	The contaminated filter cake would require off-site disposal. There could be approximately 500 cubic yards of residuals and these could be treated in an off-site incinerator.
Availability of Necessary Equipment and Specialists	The availability of vendors to perform soil washing is limited.
Availability of Technology	The availability of vendors to perform soil washing is limited.
Costs	
Capital Cost	$4,885,000
Present Worth of Operation and Maintenance Cost	$108,000
Net Present Worth Cost	$4,993,000

TABLE 10-8
COST SUMMARY TABLE
ALTERNATIVE DBG-SB7: ON-SITE INCINERATION

FEASIBILITY STUDY
DETERRENT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM	TOTAL COST
DIRECT COST	
Site Preparation and mob/demob	$ 2,007,000
Contaminated soil delineation	130,000
Excavate contaminated soil	220,000
Backfill soil	167,000
Incineration	2,433,000
TOTAL DIRECT COST	$ 4,957,000
INDIRECT COST	
Health and Safety @ 5% of Total Direct Cost	$ 248,000
Legal, Administration, Permitting @ 5% of Total Direct Cost	248,000
Engineering @ 10% of Total Direct Cost	496,000
Services During Construction @ 10% of Total Direct Cost	496,000
TOTAL INDIRECT COST	$ 1,488,000
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$ 6,445,000
OPERATING AND MAINTENANCE COSTS	
Total Annual Post Closure Maintenance Costs	$ 7,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	$ 108,000
TOTAL COST FOR SB-7 ON-SITE INCINERATION	$ 6,553,000

TABLE 10-9
DETAILED ANALYSIS - ALTERNATIVE DBG-SB7
DETERRENT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB7 ON-SITE INCINERATION
Overall Protection of Human Health and the Environment	
Human Health Protection	Under the on-site incineration alternative, contaminated soils are removed and treated. Therefore, this alternative achieves remedial action objectives for subsurface soils at the Deterrent Burning Ground.
Environmental Protection	There is no environmental risk associated with subsurface soils at the Deterrent Burning Ground.
Compliance with ARARs	
Chemical-specific	There are no promulgated chemical-specific ARARs for soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. The on-site incineration alternative would meet RGs for Deterrent Burning Ground soils.
Location-specific	There are no location-specific ARARs.
Action-specific	Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and general and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards. It is presumed that on-site incineration would comply with all RCRA requirements for hazardous waste incinerators (40 CFR Subpart O), and all applicable Clean Air Act requirements (40 CFR 50, 52, 60, and 61). Any additional RCRA permits would be obtained as necessary.

TABLE 10-9
DETAILED ANALYSIS - ALTERNATIVE DBG-SB7
DETERRENT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB7 ON-SITE INCINERATION
	RCRA, Land Disposal Restrictions (LDRs); (40 CFR Part 268) may apply to C6H6 waste disposed of in the waste pits. The C6H6 waste has been identified as a listed hazardous waste from non-specific sources (i.e., F005), per 40 CFR Part 261.31. As such, C6H6-contaminated soil may be subject to LDRs and, if excavated, must be treated so that it no longer "contains" C6H6 or treated to a concentration level prior to disposal in a RCRA Subtitle C permitted facility. In addition, 24DNT-contaminated soil in the waste pits would be characteristically hazardous if it exceeds the TCLP threshold for 24DNT waste. If classified as hazardous, and 24DNT-contaminated soil is excavated, the "characteristic" would have to be removed from the soil prior to disposal or placement on site.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Under the on-site incineration alternative, contaminated soils are excavated and treated at the Propellant Burning Ground. Fly ash from the incinerator will be transported off-site. Only soils meeting RGs will be used as clean backfill. Therefore, residual risk to future construction workers doing intrusive work would be eliminated after treatment as well as potential for leaching.
Adequacy and Reliability of Controls	On-site incineration of the soil would permanently reduce contaminant concentrations to below RGs. The potential would no longer exist for intrusive work or leaching to groundwater.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	On-site incineration would be used to thermally destroy 24DNT contaminants in subsurface soils.
Amount Destroyed or Treated	It is estimated that 5,700 cubic yards of contaminated soil would be excavated and treated by incineration. Concentrations of 24DNT in the soil will be reduced to below 4.29 mg/kg.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	Incineration thermally destroys the contaminant in the soil matrix, therefore toxicity would be reduced. Clean soil would be returned to the excavation, therefore the mobility of the contaminant through the soil would be reduced. The volume of contaminated soil would be reduced from 5,700 cubic yards to 1,140 cubic yards of fly ash containing inorganics.

continued

TABLE 10-9
DETAILED ANALYSIS - ALTERNATIVE DBG-SB7
DETERRENT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB7 ON-SITE INCINERATION
Degree to Which Treatment is Irreversible	Incineration thermally destroys the contaminant in the soil, therefore treatment is permanent.
Type and Quantity of Residuals Remaining After Treatment	Approximately 1,140 cubic yards of fly ash containing inorganic materials would be a residual of the incineration process and would require off-site disposal.
Short-term Effectiveness	
Protection of Community During Remedial Action	Although the incinerator would destroy and remove 99.9 percent of contaminants in the feed material per the operating permit, air emissions could contain traces of contaminants. However, the incinerator would be operating in a isolated portion of BAAP (i.e., Contaminated Waste Area) and no residences or active BAAP facilities are present within a mile of the site. Modeling of emission dispersal, as is normally conducted prior to permitting incinerators, is expected to indicate that the risk to human receptors downwind of the incinerator is minor.
Protection of Workers During Remedial Action	Air monitoring would be conducted at the site during excavation and incineration activities. OSHA and other health and safety requirements which limit worker exposure to inhalation hazards would be enforced. If site activities resulted in unacceptable levels of air contaminants, operations would be modified to protect workers.
Environmental Impacts	The waste pit area is not considered a critical wildlife habitat and the impact to the ecological community during soil excavation and backfill is expected to be minor. Potential impacts to ecological receptors from incinerator emissions are difficult to estimate but concentrations and the associated risk in the vicinity of the incinerator are expected to be low.
Time Until Remedial Action Objectives Are Achieved	Site preparation, excavation and transportation of soils, and mobilization of the treatment facility is expected to take 2 to 3 months. Treatment of soils from the Deterrent Burning Ground is expected to be complete in 6 to 8 weeks. Disposal, backfilling of treated soils, and overall site cleanup could take an additional month.
Implementability	
Ability to Construct and Operate the Technology	Permanent facility construction is not included with this alternative. The incinerator is a mobile, skid-mounted treatment unit. Vendors are available to operate their units.

continued

TABLE 10-9
DETAILED ANALYSIS - ALTERNATIVE DBG-SB7
DETERRENT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB7 ON-SITE INCINERATION
Reliability of the Technology	Incineration is the most effective and proven method for destruction of explosive contaminated soil (Keehan, Myler, and Sisk, 1990).
Ease of Undertaking Remedial Actions, if Necessary	Incineration would not limit or interfere with the ability to perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	A mobile laboratory would be available on-site with a colorimetric spectrophotometer capable of analyzing for residual 24DNT in soils.
Ability to Obtain Approvals and Coordinate with Other Agencies	The process for permitting an incinerator would be long and difficult. Extensive modeling of incinerator emissions may be required to show that potential receptors are not at risk.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Approximately 1,140 cubic yards of fly ash would require off-site disposal. A hazardous waste landfill is located 108 miles away.
Availability of Necessary Equipment and Specialists	On-site incineration services are readily available.
Availability of Technology	On-site incineration services are readily available.
Costs	
Capital Cost	$6,445,000
Present Worth of Operation and Maintenance Cost	$108,000
Net Present Worth Cost	$6,553,000

TABLE 10-10
COST SUMMARY TABLE
ALTERNATIVE DBG-SB8: ON-SITE COMPOSTING

FEASIBILITY STUDY
DETERRENT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM	TOTAL COST
DIRECT COST	
Site Preparation and mob/demob	$ 536,000
Contaminated soil delineation	130,000
Excavate contaminated soil	235,000
Backfill soil	163,000
Composting	1,498,000
TOTAL DIRECT COST	**$ 2,562,000**
INDIRECT COST	
Health and Safety @ 5% of Total Direct Cost	$ 128,000
Legal, Administration, Permitting @ 5% of Total Direct Cost	128,000
Engineering @ 10% of Total Direct Cost	256,000
Services During Construction @ 10% of Total Direct Cost	256,000
TOTAL INDIRECT COST	**$ 768,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$ 3,330,000**
OPERATING AND MAINTENANCE COSTS	
Annual O&M of Composting System	$ 542,000
Total Present worth of O&M Costs (5% for two years)	1,008,000
Total annual post closure maintenance costs	$8,000
Total Present worth of O&M Costs (5% for thirty years)	$123,000
TOTAL PRESENT WORTH OF O&M COSTS	**$ 1,131,000**
TOTAL COST FOR SB-8 ON-SITE COMPOSTING	**$ 4,461,000**

TABLE 10-11
DETAILED ANALYSIS - ALTERNATIVE DBG-SB8
DETERRENT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB8 COMPOSTING
Overall Protection of Human Health and the Environment	
Human Health Protection	Provides protection of human health by reducing DNT concentrations in the finished compost to below RG concentrations that are based on protective risk levels.
Environmental Protection	Provides protection of the environment by achieving RG concentrations in the finished compost.
Compliance with ARARs	
Chemical-specific	There are no promulgated chemical-specific ARARs for soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. The composting alternative is expected to meet RGs for Deterrent Burning Ground soils.
Location-specific	
Action-specific	General RCRA requirements pertaining to permitted Hazardous Waste TSD units would be addressed by the composting alternative. General WDNR and NAAQS requirements pertaining to the control of air emissions would be addressed by this alternative. CAA-NAAQS, RCRA and WDNR requirements pertaining to excavation would be addressed by this alternative. General RCRA requirements pertaining to land disposal would be addressed in the composting alternative. Federal OSHA requirements to protect worker health and safety would be followed during any site work. Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA. RCRA, Land Disposal Restrictions (LDRs); (40 CFR Part 268) may apply to C6H6 waste disposed of in the waste pits. The C6H6 waste has been identified as a listed hazardous waste from non-specific sources (i.e., F005), per 40 CFR Part 261.31. As such, C6H6-contaminated soil may be subject to LDRs and, if excavated, must be treated so that it no longer "contains" C6H6 or treated to a concentration level prior to disposal in a RCRA Subtitle C permitted facility. In addition, 24DNT-contaminated soil in the waste pits would be characteristically hazardous if it exceeds the TCLP threshold for 24DNT waste. If classified as hazardous, and 24DNT-contaminated soil is excavated, the "characteristic" would have to be removed from the soil prior to disposal or placement on site.

continued

TABLE 10-11
DETAILED ANALYSIS - ALTERNATIVE DBG-SB8
DETERRENT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB8 COMPOSTING
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Effectiveness is expected to be long-term since contaminant concentrations are reduced to levels that protect human health and environment.
Adequacy and Reliability of Controls	Since the final compost does not contain constituents that pose a risk to human health and environment and contains native microorganisms, the treated soil would not require long-term management and controls.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	The treatment process utilizes native microorganisms and agricultural waste amendments that are not toxic to human health and environment.
Amount Destroyed or Treated	The contaminant of concern (DNT) is destroyed in excess of 95% and achieves RG concentrations.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	Composting reduces soil toxicity as measured by bacterial mutagenicity and aquatic toxicity by 88 to 98%. Residual material is nutrient-rich compost (which may imply greater volume of nitrates). No other waste streams are generated in this process.
Short-term Effectiveness	
Protection of Community During Remedial Action	The remote location of the composting site in a secured military facility would prevent unauthorized public access to the site. The distance of the BAAP property boundary from the composting site would provide adequate dispersal of any odors and any airborne contaminants.
Protection of Workers During Remedial Action	Protection of workers during operation will be accomplished with personal protective gear, safety procedures and process monitoring to be specified in the Health and Safety Plan for the remedial action.
Environmental Impacts	No protected species or sensitive land areas are expected to be affected during remediation. Land areas disturbed to implement composting operation would be restored following project completion.
Time Until Remedial Action Objectives Are Achieved	Composting operation can be completed within approximately two years.

continued

TABLE 10-11
DETAILED ANALYSIS - ALTERNATIVE DBG-SB8
DETERRENT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-SB8 COMPOSTING
Implementability	
Ability to Construct and Operate the Technology	Construction of the composting facility poses no unusual design or construction problems. Operation does not require unusual skills or knowledge and is commonly practiced for agricultural wastes.
Reliability of the Technology	The general technical feasibility of composting explosives-contaminated soil have been successfully demonstrated at a similar U.S.Army site. Site specific treatability investigations will be necessary to confirm feasibility at BAAP prior to full scale design and construction.
Ability to Monitor Effectiveness of Remedy	Effectiveness of the composting process will be monitored with sampling and analysis of the compost on a regular basis until RGs are achieved.
Ability to Obtain Approvals and Coordinate with Other Agencies	Administratively, composting of explosives-contaminated soil is generally supported by EPA as a potentially viable and cost-effective technology. This technology has been identified as one of the selected alternatives in the Record of Decision by EPA at a similar U.S.Army site. Obtaining permits and approvals of regulatory agencies for this alternative is not expected to pose a major administrative difficulty.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Off-site Treatment, Storage, and Disposal facility and services are not required for this alternative since treatment residuals will be backfilled into the waste pits.
Availability of Necessary Equipment and Specialists	Composting is a well developed technology used extensively throughout the country. Availability of equipment is not a limitation.
Costs	
Capital Cost	$3,330,000
Present Worth of Operation and Maintenance Cost	$1,131,000
Net Present Worth Cost	$4,461,000

TABLE 10-12
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND SUBSURFACE SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative DBG-SB1: Minimal Action	Protective of human health, however, contaminated subsurface soils will remain on site and pose a risk to construction workers doing intrusive work and groundwater.	No action would be taken at the site, therefore location- and action-specific ARARs would not apply. Proposed Chapter NR 720 clean-up standards would not be met.	Would be capable of protecting human health through institutional controls.	Contamination is not treated or destroyed; no reduction in toxicity, mobility, or volume.	No implementation, therefore no adverse community or environmental impacts during implementation.	No implementability concerns.	Total Present Worth: $118,000 Capital Costs: $10,000 Annual O&M Costs: $108,000
Alternative DBG-SB2: Capping	Protective of human health and ground-water; however, subsurface soils will remain on site and pose a risk if the integrity of the cap is violated.	This alternative could meet the intent of NR 720 clean-up standards. Location-specific ARARs for landfills would apply. Action-specific ARARs would be addressed.	Would be capable of protecting human health through institutional controls. Would be capable of protecting groundwater.	Contamination is not treated or destroyed; no reduction in toxicity, mobility, or volume.	Fugitive dust from construction site could result in risk to the community.	Landfill contractor must use employees who have current OSHA site worker protection training.	Total Present Worth: $642,000 Capital Costs: $534,000 Annual O&M Costs: $108,000
Alternative DBG-SB4: Soil Washing	Protective of human health because soils will be excavated and treated to below RGs.	Location-specific ARARs for landfills would apply. Action-specific ARARs would be addressed. Proposed Chapter NR 720 clean-up standards would be met.	Would be capable of maintaining protection of human health and groundwater because contaminants are removed and permanently treated.	24DNT would be treated on-site. Residuals generated from treatment would be appropriately disposed of off-site.	Fugitive dust from construction site could result in risk to the community. Exposing contaminated soils increases risk to site workers.	Excavation contractor must use employees who have current OSHA Site Worker Protection training. Soil washing vendors have limited availability. Treatability testing required before implementation.	Total Present Worth: $4,993,000 Capital Costs: $4,885,000 Annual O&M Costs: $108,000

continued

Table 10-12
Comparative Summary of Remedial Alternatives
Deterrent Burning Ground Subsurface Soil

Feasibility Study
Badger Army Ammunition Plant

Alternative	Overall Protection	Compliance with ARARs	Effectiveness: Long-Term	Reduction in Toxicity, Mobility, and Volume	Effectiveness: Short-Term	Implementability	Cost
Alternative DBG-SB7: On-Site Incineration	Protective of human health because soils will be excavated and treated to below RGs.	Location-specific ARARs for landfills would apply. Action-specific ARARs would be addressed. Proposed Chapter NR 720 clean-up standards would be met.	Would be capable of maintaining protection of human health and groundwater because contaminants are removed and permanently treated.	24DNT would be treated on-base. Residuals generated from treatment would be appropriately disposed of off-site.	Fugitive dust from construction site could result in risk to the community. Exposing contaminated soils increases risk to site workers. Transportation of contaminated soils across the base for treatment increases risk.	Excavation contractor must use employees who have current OSHA Site Worker Protection training. Will only be implemented if on-site incineration is implemented at the Propellant Burning Ground.	Total Present Worth: $6,553,000 Capital Costs: $6,445,000 Annual O&M Costs: $108,000
Alternative DBG-SB8: Composting	Protective of human health because soils will be excavated and treated to below RGs.	Location-specific ARARs for landfills would apply. Action-specific ARARs would be addressed. Proposed Chapter NR 720 soil clean-up standards would be met.	Would be capable of maintaining protection of human health and groundwater because contaminants are removed and permanently treated.	24DNT would be treated on-site. No residuals resulting from treatment.	Fugitive dust from construction site could result in risk to the community. Exposing contaminated soils increases risk to site workers.	Excavation contractor must use employees who have current OSHA Site Worker Protection training.	Total Present Worth: $4,461,000 Capital Costs: $3,330,000 Annual O&M Costs: $1,131,000

TABLE 10–13
COST SUMMARY TABLE
ALTERNATIVE DBG–GW1: MINIMAL ACTION

FEASIBILITY STUDY
DETERRENT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST		
Institutional controls	$	10,000
TOTAL DIRECT COST	$	10,000
INDIRECT COST		
Health and Safety @ 5% of Total Direct Cost	$	0
Legal, Administration, Permitting @ 5% of Total Direct Cost		0
Engineering @ 10% of Total Direct Cost		0
Services During Construction @ 10% of Total Direct Cost		0
TOTAL INDIRECT COST	$	0
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$	10,000
OPERATING AND MAINTENANCE COSTS		
Total cost replacement wells	$	11,000
Total present worth of replacement wells in year 16 @ 5%	$	5,000
Total Annual Operating and Maintenance Costs	$	54,000
Total present worth of annual O&M costs (5% for 30 years)	$	830,000
TOTAL PRESENT WORTH OF O&M COSTS	$	835,000
TOTAL COST FOR GW–1 MINIMAL ACTION	$	845,000

TABLE 10-14
DETAILED ANALYSIS - ALTERNATIVE DBG-GW1 (MINIMAL ACTION)

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW1 - MINIMAL ACTION
Overall Protection of Human Health and the Environment	
Human Health Protection	Under existing conditions, there is limited potential for public exposure to contaminated groundwater. Hydrogeologic analyses suggest groundwater flow within the vicinity of the site contaminants largely remains on-post before migrating to the Wisconsin River south of BAAP.
Environmental Protection	There are no risks to environmental receptors.
Compliance with ARARs	
Chemical-specific	Would not meet chemical-specific ARARs for on-post groundwater. Removal of source wastes may decrease levels of contaminants in groundwater.
Location-specific	Location-specific ARARs pertaining to wetlands and surface water do not apply to this alternative.
Action-specific	Action-specific ARARs do not apply to this alternative because no action would be taken.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Currently, on-post groundwater does not meet RGs. However, residual risk is low because of limited potential public exposure to elevated groundwater system. The residual risk may eventually decrease by chemical and/or biological degradation.
Adequacy and Reliability of Controls	Not Applicable. No controls would be used in this alternative.
Reduction of Toxicity, Mobility, or Volume through Treatment	
Treatment Process Used and Materials Treated	Not Applicable. No treatment is used in this alternative.
Amount Destroyed or Treated	No contamination is destroyed or treated.
Degree of Expected Reductions of Toxicity, Mobility, or Volume through Treatment	No reduction of toxicity, mobility, or volume through treatment because treatment is not used.
Degree to Which Treatment is Irreversible	No treatment is used.
Type and Quantity of Residuals Remaining After Treatment	No treatment is used.
Short-term Effectiveness	
Protection of Community during Remedial Action	No adverse or beneficial impact to the community would occur because no remedial actions would be implemented.
Worker Protection during Remedial Action	No adverse worker impacts because no remedial actions would be implemented.
Environmental Impacts	No direct or indirect short-term adverse ecological effects would occur because no remedial actions would be implemented.

continued

TABLE 10-14
DETAILED ANALYSIS - ALTERNATIVE DBG-GW1 (MINIMAL ACTION)

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW1 - MINIMAL ACTION
Time until Remedial Action Objectives are Achieved	Unknown. Remedial action would not occur; however, the aquifer could cleanse itself over many years.
Implementability	
Ability to Construct and Operate the Technology	No construction would occur.
Reliability of Technology	No technologies would be used.
Ease of Undertaking Additional Remedial Action, if Necessary	No action would not limit or interfere with the ability to perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Monitoring program can be implemented using existing monitoring wells.
Ability to Obtain Approvals and Coordinate with other Agencies	No permits would be required. Coordination with state and local officials is required to implement institutional controls.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Not required.
Availability of Necessary Equipment and Specialists	No equipment would be required.
Availability of Technology	No technologies would be used.
Cost	
Capital Cost	$10,000
Present Worth of Operation and Maintenance Cost	$835,000
Net Present Worth Cost	$845,000

Notes:

ARARs = Applicable or Relevant and Appropriate Requirements
RG = Remediation Goal

TABLE 10–15
COST SUMMARY TABLE
ALTERNATIVE DBG–GW2: GROUNDWATER EXTRACTION, TRANSPORTATION, TREATMENT

FEASIBILITY STUDY
DETERRENT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST		
Site preparation and mob/demob	$	200,000
Extraction well system		753,000
TOTAL DIRECT COST	**$**	**953,000**
INDIRECT COST		
Health and Safety @ 5% of Total Direct Cost	$	48,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		48,000
Engineering @ 10% of Total Direct Cost		95,000
Services During Construction @ 10% of Total Direct Cost		95,000
TOTAL INDIRECT COST	**$**	**286,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**1,239,000**
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	50,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$**	**769,000**
TOTAL COST FOR GW–2 GROUNDWATER EXTRACTION, TRANSPORTATION, TREATMENT	**$**	**2,008,000**

TABLE 10-16
DETAILED ANALYSIS - ALTERNATIVE DBG-GW2
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW2 IRM AND CARBON ADSORPTION
Overall Protection of Human Health and the Environment	
Human Health Protection	This alternative will not achieve all remedial action objectives. Extraction of contaminated groundwater would result in reduced exposure to some contaminants. However, until the source area is satisfactorily identified and remediated, groundwater in the elevated aquifer will potentially be recontaminated and the potential for future exposure to contaminated groundwater still exists. Given the hydrological characteristics of the elevated aquifer, it is unlikely to be used as a drinking water source. Nonetheless, this aquifer merges with the regional aquifer which may be used as a drinking water source.
Environmental Protection	There is no environmental risk associated with groundwater at the Deterrent Burning Ground.
Compliance with ARARs	
Chemical-specific	Uncertain whether chemical-specific ARARs would be met with this alternative. Source area for contamination of Deterrent Burning Groundwater has not been identified. Until source area has been identified and treated it is likely it will continue to contaminate groundwater beneath the site.
Location-specific	No location-specific ARARs.
Action-specific	Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards.

continued

TABLE 10-16
DETAILED ANALYSIS - ALTERNATIVE DBG-GW2
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW2 IRM AND CARBON ADSORPTION
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	This alternative would be implemented to comply with NR 720, WESs and secondary drinking water standards. The standards were developed to minimize risk; therefore, the magnitude of the residual risk attributed to treated groundwater would be minimal. Treatment of groundwater is not a permanent solution because it would continue indefinitely unless the source is removed. There may be an inherent residual risk unless the source is identified and remediated. However, residual risk is low because of limited potential public exposure to elevated groundwater system.
Adequacy and Reliability of Controls	The effectiveness of the groundwater extraction system is limited due to the hydrogeology of the elevated aquifer. Unless the source is identified and remediated, the groundwater extraction system, the treatment system, and the groundwater monitoring program will continue indefinitely.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Carbon adsorption would be used to reduce 26DNT and 112TCE from the groundwater. Thermal reactivation of spent carbon would destroy the contaminants.
Amount Destroyed or Treated	It is unknown how much of each compound will be treated over a 30-year period. Until the source area can be identified and remediated, it may continue to contaminate the aquifer.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	The proposed extraction system would reduce the mobility of contaminants in the groundwater at the Deterrent Burning Ground. The toxicity of the groundwater is substantially reduced by removing the contaminants in the carbon and thermally destroying them during reactivation. The volume of contaminants will not be substantially reduced unless the source area can be identified and remediated.
Degree to Which Treatment is Irreversible	Contaminants would be destroyed during thermal reactivation of the spent carbon.
Type and Quantity of Residuals Remaining After Treatment	Assuming complete destruction of contaminants in the spent carbon during thermal reactivation, no residuals would remain.

continued

Table 10-16
Detailed Analysis - Alternative DBG-GW2
Deterrent Burning Ground Groundwater

Feasibility Study
Badger Army Ammunition Plant

Evaluation Criteria	Alternative DBG-GW2 IRM and Carbon Adsorption
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation. There are no residences close enough by to be affected by noise or dust generated by installation of extraction wells and associated piping. Potential threats to the community exist in the transportation of groundwater to the treatment facility at the Propellant Burning Ground.
Protection of Workers During Remedial Action	Threats to site worker health are minimal during well and pipe installation, however workers should follow safe working practices and wear protective clothing.
Environmental Impacts	Great care must be taken when constructing the extraction wells to avoid transferring contaminants from the elevated aquifer to the regional aquifer. Although minimal, there exist opportunities for adverse impacts to the environment during the transportation of groundwater to the treatment facility at the Propellant Burning Ground.
Time Until Remedial Action Objectives Are Achieved	Until the source area can be identified and treated, the time until RGs can be reached is uncertain.
Implementability	
Ability to Construct and Operate the Technology	The installation of extraction wells is a complicated construction task. The IRM upgrade and new groundwater treatment facility are implemented with the groundwater alternatives for the Propellant Burning Ground.
Reliability of the Technology	The thinness of the elevated aquifer is not likely to provide the cone of influence needed to draw the contaminants to the extraction well. Carbon adsorption is a proven method for removing organic contaminants from groundwater. The existing IRM facility (and associated carbon adsorption system) has been successfully operated for more than three years treating Propellant Burning Ground groundwater and is expected to be reliable treatment for Deterrent Burning Ground groundwater.
Ease of Undertaking Additional Remedial Actions, if Necessary	This alternative would not preclude or hinder additional remedial actions. The groundwater extraction system would not interfere with soil remediation. The groundwater treatment facility would be located away from the site and would not interfere with soil remediation.
Ability to Monitor Effectiveness of Remedy	Groundwater quality can be monitored using existing wells. The effectiveness of the treatment system will be monitored through the sampling program established with the Propellant Burning Ground alternative in Subsection 9.4.2.1.

continued

TABLE 10-16
DETAILED ANALYSIS - ALTERNATIVE DBG-GW2
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW2 IRM AND CARBON ADSORPTION
Ability to Obtain Approvals and Coordinate with Other Agencies	No special approvals are anticipated.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Facilities which have sufficient capacity for the reactivation of spent carbon are available.
Availability of Necessary Equipment and Specialists	Local contractors and materials are available to perform installation and maintenance functions. Contractors are also readily available to provide groundwater transportation services from the Deterrent Burning Ground to the groundwater treatment facility at the Propellant Burning Ground. Carbon adsorption equipment and expertise is available from several vendors.
Availability of Technology	These technologies are readily available. More than one vendor would be able to provide a competitive bid.
Costs	
Capital Cost	$1,239,000
Present Worth of Operation and Maintenance Cost	$769,000
Net Present Worth Cost	$2,008,000

TABLE 10-17
COST SUMMARY TABLE
ALTERNATIVE DBG-GW4: GROUNDWATER EXTRACTION, TRANSPORTATION, TREATMENT

FEASIBILITY STUDY
DETERRENT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM	TOTAL COST
DIRECT COST	
Site preparation and mob/demob	$ 200,000
Extraction well system	753,000
TOTAL DIRECT COST	**$ 953,000**
INDIRECT COST	
Health and Safety @ 5% of Total Direct Cost	$ 48,000
Legal, Administration, Permitting @ 5% of Total Direct Cost	48,000
Engineering @ 10% of Total Direct Cost	95,000
Services During Construction @ 10% of Total Direct Cost	95,000
TOTAL INDIRECT COST	**$ 286,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$ 1,239,000**
OPERATING AND MAINTENANCE COSTS	
Total Annual Operating and Maintenance Costs	$ 50,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$ 769,000**
TOTAL COST FOR GW-4 GROUNDWATER EXTRACTION, TRANSPORTATION, TREATMENT	**$ 2,008,000**

TABLE 10-18
DETAILED ANALYSIS - ALTERNATIVE DBG-GW4
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW4 IRM AND AIR STRIPPING - CARBON ADSORPTION
Overall Protection of Human Health and the Environment	
Human Health Protection	This alternative will not achieve all remedial action objectives. Extraction of contaminated groundwater would result in reduced exposure to some contaminants. However, until the source area is satisfactorily identified and remediated, groundwater in the elevated aquifer will potentially be recontaminated and the potential for future exposure to contaminated groundwater still exists. Given the hydrological characteristics of the elevated aquifer, it is unlikely to be used as a drinking water source. Nonetheless, this aquifer merges with the regional aquifer which may be used as a drinking water source.
Environmental Protection	There is no environmental risk associated with groundwater at the Deterrent Burning Ground.
Compliance with ARARs	
Chemical-specific	Uncertain whether chemical-specific ARARs would be met with this alternative. Source area for contamination of Deterrent Burning Groundwater has not been identified. Until source area has been identified and treated it is likely it will continue to contaminate groundwater beneath the site.
Location-specific	No location-specific ARARs.
Action-specific	Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards. Air emissions from the air strippers would be limited per a permit issued in accordance with WAC Chapter NR 445. In addition, WAC Chapter NR 419 identifies a daily limit for total VOCs emitted from a facility. It is presumed that emission treatment systems associated with the air strippers would keep the facility in compliance.

continued

TABLE 10-18
DETAILED ANALYSIS - ALTERNATIVE DBG-GW4
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW4 IRM AND AIR STRIPPING - CARBON ADSORPTION
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	This alternative would be implemented to comply with NR 270, WESs and secondary drinking water standards. The standards were developed to minimize risk; therefore, the magnitude of the residual risk attributed to treated groundwater would be minimal. Treatment of groundwater is not a permanent solution because it would continue indefinitely unless the source is removed. There may be an inherent residual risk unless the source is identified and remediated. However, residual risk is low because of limited potential public exposure to elevated groundwater system.
Adequacy and Reliability of Controls	The effectiveness of the groundwater extraction system is limited due to the hydrogeology of the elevated aquifer. Unless the source is identified and remediated, the groundwater extraction system, the treatment system, and the groundwater monitoring program will continue indefinitely.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Air strippers with vapor-phase carbon and aqueous-phase carbon would be used to reduce 112TCE and 26DNT, respectively. Thermal reactivation of spent carbon would destroy the contaminants.
Amount Destroyed or Treated	It is unknown how much of each compound will be treated over a 30-year period. Until the source area can be identified and treated, it may continue to contaminate the aquifer.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	The proposed extraction system would reduce the mobility of contaminants in the groundwater at the Deterrent Burning Ground. The toxicity of the groundwater is substantially reduced by removing the contaminants in the air stripper and the carbon and by thermally destroying them during carbon reactivation. The volume of contaminants will not be substantially reduced unless the source area can be identified and remediated.
Degree to Which Treatment is Irreversible	Contaminants are destroyed during carbon reactivation for both vapor and aqueous phase carbons.
Type and Quantity of Residuals Remaining After Treatment	Assuming complete destruction of contaminants in the spent carbon during thermal reactivation, no residuals would remain.

continued

TABLE 10-18
DETAILED ANALYSIS - ALTERNATIVE DBG-GW4
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW4 IRM AND AIR STRIPPING - CARBON ADSORPTION
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation. There are no residences close enough by to be affected by noise or dust generated by installation of extraction wells and associated piping. Potential threats to the community exist in the transportation of groundwater to the treatment facility at the Propellant Burning Ground.
Protection of Workers During Remedial Action	Threats to site worker health are minimal during well and pipe installation, however workers should follow safe working practices and wear protective clothing.
Environmental Impacts	Great care must be taken when constructing the extraction wells to avoid transferring contaminants from the elevated aquifer to the regional aquifer. Although minimal, there exist opportunities for adverse impacts to the environment during the transportation of groundwater to the treatment facility at the Propellant Burning Ground.
Time Until Remedial Action Objectives Are Achieved	Until the source area can be identified and treated, the time until RGs can be reached is uncertain.
Implementability	
Ability to Construct and Operate the Technology	The installation of extraction wells is a complicated construction task. The IRM upgrade and new groundwater treatment facility are implemented with the groundwater alternatives for the Propellant Burning Ground.
Reliability of the Technology	The thinness of the elevated aquifer is not likely to provide the cone of influence needed to draw the contaminants to the extraction well. Air stripping and carbon adsorption are proven technologies for treating organics in groundwater and off-gases and are anticipated to perform reliably in treating Deterrent Burning Ground groundwater.
Ease of Undertaking Additional Remedial Actions, if Necessary	This alternative would not preclude or hinder additional remedial actions. The extraction system would not interfere with soil remediation. The groundwater treatment system would be located away from the site and would not interfere with soil remediation.
Ability to Monitor Effectiveness of Remedy	Groundwater quality can be monitored using existing wells. The effectiveness of the treatment system will be monitored through the sampling program established with the Propellant Burning Ground alternative in Subsection 9.4.3.1.
Ability to Obtain Approvals and Coordinate with Other Agencies	Sampling and analysis of air stripper emissions may have to be conducted prior to receiving an air permit.

continued

TABLE 10-18
DETAILED ANALYSIS - ALTERNATIVE DBG-GW4
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW4 IRM AND AIR STRIPPING - CARBON ADSORPTION
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Facilities which have sufficient capacity for the reactivation of spent carbon are available.
Availability of Necessary Equipment and Specialists	Local contractors and materials are available to perform installation and maintenance functions. Contractors are also readily available to provide groundwater transportation services from the Deterrent Burning Ground to the groundwater treatment facility at the Propellant Burning Ground. Carbon adsorption and air stripping equipment and expertise is available from several vendors.
Availability of Technology	These technologies are readily available. More than one vendor would be able to provide a competitive bid.
Costs	
Capital Cost	$1,239,000
Present Worth of Operation and Maintenance Cost	$769,000
Net Present Worth Cost	$2,008,000

TABLE 10-19
COST SUMMARY TABLE
ALTERNATIVE DBG-GW5: GROUNDWATER EXTRACTION, TRANSPORTATION, TREATMENT

FEASIBILITY STUDY
DETERRENT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST		
Site preparation and mob/demob	$	200,000
Extraction well system		753,000
TOTAL DIRECT COST	**$**	**953,000**
INDIRECT COST		
Health and Safety @ 5% of Total Direct Cost	$	48,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		48,000
Engineering @ 10% of Total Direct Cost		95,000
Services During Construction @ 10% of Total Direct Cost		95,000
TOTAL INDIRECT COST	**$**	**286,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**1,239,000**
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	50,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$**	**769,000**
TOTAL COST FOR GW-5 GROUNDWATER EXTRACTION, TRANSPORTATION, TREATMENT	**$**	**2,008,000**

TABLE 10-20
DETAILED ANALYSIS - ALTERNATIVE DBG-GW5
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW5 IRM AND RESIN ADSORPTION
Overall Protection of Human Health and the Environment	
Human Health Protection	This alternative will not achieve all remedial action objectives. Extraction of contaminated groundwater would result in reduced exposure to some contaminants. However, until the source area is satisfactorily identified and remediated, groundwater in the elevated aquifer will potentially be recontaminated and the potential for future exposure to contaminated groundwater still exists. Given the hydrological characteristics of the elevated aquifer, it is unlikely to be used as a drinking water source. Nonetheless, this aquifer merges with the regional aquifer which may be used as a drinking water source.
Environmental Protection	There is no environmental risk associated with groundwater at the Deterrent Burning Ground.
Compliance with ARARs	
Chemical-specific	Uncertain whether chemical-specific ARARs would be met with this alternative. Source area for contamination of Deterrent Burning Groundwater has not been identified. Until source area has been identified and treated it is likely it will continue to contaminate groundwater beneath the site.
Location-specific	No location-specific ARARs.
Action-specific	Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards.

continued

TABLE 10-20
DETAILED ANALYSIS - ALTERNATIVE DBG-GW5
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW5 IRM AND RESIN ADSORPTION
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	This alternative would be implemented to comply with NR 720, WESs, and secondary drinking water standards. The standards were developed to minimize risk; therefore, the magnitude of the residual risk attributed to treated groundwater would be minimal. Treatment of groundwater is not a permanent solution because it would continue indefinitely unless the source is removed. There may be an inherent residual risk unless the source is identified and remediated. However, residual risk is low because of limited potential public exposure to elevated groundwater system.
Adequacy and Reliability of Controls	The effectiveness of the groundwater extraction system is limited due to the hydrogeology of the elevated aquifer. Unless the source is identified and remediated, the groundwater extraction system, the treatment system, and the groundwater monitoring program will continue indefinitely.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Resin adsorption would be used in the new groundwater treatment facility to reduce 112TCE and 26DNT. The IRM facility would continue to use carbon adsorption followed by air stripping polish. Contaminants in the concentrated organic phase generated during in situ resin regeneration would be destroyed in an incinerator. Thermal reactivation of spent carbon from the IRM facility would also destroy contaminants.
Amount Destroyed or Treated	It is unknown how much of each compound will be treated over a 30-year period. Until the source area can be identified and treated, it may continue to contaminate the aquifer.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	The proposed extraction system would reduce the mobility of contaminants in the groundwater at the Deterrent Burning Ground. The toxicity of the groundwater is substantially reduced by transferring the contaminants to the resin. The concentrated contaminants from resin bed regeneration would be destroyed in an incinerator. The volume of contaminants will not be substantially reduced unless the source area can be identified and remediated.
Degree to Which Treatment is Irreversible	Contaminants are destroyed after regeneration of the resin bed by incineration and by thermal reactivation of the spent carbon.

continued

TABLE 10-20
DETAILED ANALYSIS - ALTERNATIVE DBG-GW5
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW5 IRM AND RESIN ADSORPTION
Type and Quantity of Residuals Remaining After Treatment	Assuming complete destruction of the organic phase during incineration and complete destruction of adsorbed contaminants in spent carbon during thermal reactivation, no residuals would remain.
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation. There are no residences close enough by to be affected by noise or dust generated by installation of extraction wells and associated piping. Potential threats to the community exist in the transportation of groundwater to the treatment facility at the Propellant Burning Ground.
Protection of Workers During Remedial Action	Threats to site worker health are minimal during well and pipe installation, however workers should follow safe working practices and wear protective clothing.
Environmental Impacts	Great care must be taken when constructing the extraction wells to avoid transferring contaminants from the elevated aquifer to the regional aquifer. Although minimal, there exist opportunities for adverse impacts to the environment during the transportation of groundwater to the treatment facility at the Propellant Burning Ground.
Time Until Remedial Action Objectives Are Achieved	Until the source area can be identified and treated, the time until RGs can be reached is uncertain.
Implementability	
Ability to Construct and Operate the Technology	The installation of extraction wells is a complicated construction task. The IRM upgrade and new groundwater treatment facility implemented with the groundwater alternatives for the Propellant Burning Ground.
Reliability of the Technology	The thinness of the elevated aquifer is not likely to provide the cone of influence needed to draw the contaminants to the extraction well. Resin adsorption is not a proven technology for removing chlorinated compounds and explosives from groundwater. Resin technology applied to treatment of water contaminated with chlorinated compounds is being developed but has not been implemented at full scale. The carbon adsorption system in the IRM has proven to be effective on groundwater from the Propellant Burning Ground and is anticipated to perform reliably in treating Deterrent Burning Ground groundwater.

continued

TABLE 10-20
DETAILED ANALYSIS - ALTERNATIVE DBG-GW5
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW5 IRM AND RESIN ADSORPTION
Ease of Undertaking Additional Remedial Actions, if Necessary	This alternative would not preclude or hinder additional remedial actions. The extraction system would not interfere with soil remediation. The groundwater treatment system would be located away from the site and would not interfere with soil remediation.
Ability to Monitor Effectiveness of Remedy	Groundwater quality can be monitored using existing wells. The effectiveness of the treatment system will be monitored through the sampling program established with the Propellant Burning Ground alternative in Subsection 9 8.4.4.1.
Ability to Obtain Approvals and Coordinate with Other Agencies	No special approvals are anticipated.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Facilities which have sufficient capacity for incineration of concentrated organic phase and reactivation of spent carbon are available.
Availability of Necessary Equipment and Specialists	Local contractors and materials are available to perform installation and maintenance functions. Contractors are also readily available to provide groundwater transportation services from the Deterrent Burning Ground to the groundwater treatment facility at the Propellant Burning Ground. Availability of resin adsorption equipment manufacturers and specialists versed in system design and operation is limited.
Availability of Technology	Resin adsorption technology for the treatment of chlorinated compounds is being developed. Information concerning treatment of explosives is unavailable.
Costs	
Capital Cost	$1,239,000
Present Worth of Operation and Maintenance Cost	$769,000
Net Present Worth Cost	$2,008,000

TABLE 10-21
COST SUMMARY TABLE
ALTERNATIVE DBG-GW6: GROUNDWATER EXTRACTION, TRANSPORTATION, TREATMENT

FEASIBILITY STUDY
DETERRENT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

ITEM	TOTAL COST
DIRECT COST	
Site preparation and mob/demob	$ 200,000
Extraction well system	753,000
TOTAL DIRECT COST	**$ 953,000**
INDIRECT COST	
Health and Safety @ 5% of Total Direct Cost	$ 48,000
Legal, Administration, Permitting @ 5% of Total Direct Cost	48,000
Engineering @ 10% of Total Direct Cost	95,000
Services During Construction @ 10% of Total Direct Cost	95,000
TOTAL INDIRECT COST	**$ 286,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$ 1,239,000**
OPERATING AND MAINTENANCE COSTS	
Total Annual Operating and Maintenance Costs	$ 50,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$ 769,000**
TOTAL COST FOR GW-6 GROUNDWATER EXTRACTION, TRANSPORTATION, TREATMENT	**$ 2,008,000**

TABLE 10-22
DETAILED ANALYSIS - ALTERNATIVE DBG-GW6
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW6 IRM AND UV/REDUCTION
Overall Protection of Human Health and the Environment	
Human Health Protection	This alternative will not achieve all remedial action objectives. Extraction of contaminated groundwater would result in reduced exposure to some contaminants. However, until the source area is satisfactorily identified and remediated, groundwater in the elevated aquifer will potentially be recontaminated and the potential for future exposure to contaminated groundwater still exists. Given the hydrological characteristics of the elevated aquifer, it is unlikely to be used as a drinking water source. Nonetheless, this aquifer merges with the regional aquifer which may be used as a drinking water source.
Environmental Protection	There is no environmental risk associated with groundwater at the Deterrent Burning Ground.
Compliance with ARARs	
Chemical-specific	Uncertain whether chemical-specific ARARs would be met with this alternative. Source area for contamination of Deterrent Burning Groundwater has not been identified. Until source area has been identified and treated it is likely it will continue to contaminate groundwater beneath the site.
Location-specific	No location-specific ARARs.
Action-specific	Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards.

continued

TABLE 10-22
DETAILED ANALYSIS - ALTERNATIVE DBG-GW6
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW6 IRM AND UV/REDUCTION
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	This alternative would be implemented to comply with WESs and secondary drinking water standards. The standards were developed to minimize risk; therefore, the magnitude of the residual risk attributed to treated groundwater would be minimal. Treatment of groundwater is not a permanent solution because it would continue indefinitely unless the source is removed. There may be an inherent residual risk unless the source is identified and remediated. However, residual risk is low because of limited potential public exposure to elevated groundwater system.
Adequacy and Reliability of Controls	The effectiveness of the groundwater extraction system is limited due to the hydrogeology of the elevated aquifer. Unless the source is identified and remediated, the groundwater extraction system, the treatment system, and the groundwater monitoring program will continue indefinitely.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	UV/reduction would be used for destruction of 112TCE and partial destruction of 26DNT in the new treatment facility. Polishing would occur in the carbon adsorption system. Aqueous-phase carbon followed by air stripper polish would be used in the IRM facility. Thermal reactivation of spent carbon from the IRM facility would destroy adsorbed contaminants.
Amount Destroyed or Treated	It is unknown how much of each compound will be treated over a 30-year period. Until the source area can be identified and treated, it may continue to contaminate the aquifer.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	The proposed extraction system would reduce the mobility of contaminants in the groundwater at the Deterrent Burning Ground. The toxicity of the groundwater is substantially reduced by destroying the contaminants with UV light. The volume of contaminants will not be substantially reduced unless the source area can be identified and remediated.
Degree to Which Treatment is Irreversible	Contaminants are destroyed during UV/reduction and by off-site thermal reactivation of spent carbon.
Type and Quantity of Residuals Remaining After Treatment	Contaminants would be destroyed in the UV/reduction process and by thermal reactivation of the spent carbon, therefore no residuals would remain.

continued

TABLE 10-22
DETAILED ANALYSIS - ALTERNATIVE DBG-GW6
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW6 IRM AND UV/REDUCTION
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation. There are no residences close enough by to be affected by noise or dust generated by installation of extraction wells and associated piping. Potential threats to the community exist in the transportation of groundwater to the treatment facility at the Propellant Burning Ground.
Protection of Workers During Remedial Action	Threats to site worker health are minimal during well and pipe installation, however workers should follow safe working practices and wear protective clothing. Chemicals used during UV reduction have been approved by the Food and Drug Administration as a food additive and would not present a hazard to treatment plant operators.
Environmental Impacts	Great care must be taken when constructing the extraction wells to avoid transferring contaminants from the elevated aquifer to the regional aquifer. Although minimal, there exist opportunities for adverse impacts to the environment during the transportation of groundwater to the treatment facility at the Propellant Burning Ground.
Time Until Remedial Action Objectives Are Achieved	Until the source area can be identified and treated, the time until RGs can be reached is uncertain.
Implementability	
Ability to Construct and Operate the Technology	The installation of extraction wells is a complicated construction task. The IRM upgrade and new groundwater treatment facility implemented with the groundwater alternatives for the Propellant Burning Ground.
Reliability of the Technology	The thinness of the elevated aquifer is not likely to provide the cone of influence needed to draw the contaminants to the extraction well. UV/reduction is a relatively new technology for treating organics in groundwater. Results from bench- and pilot-scale testing of UV reduction indicate that it has significant potential for treatment of water contaminated with chlorinated compounds. The IRM facility has proven to be effective on groundwater from the Propellant Burning Ground and is anticipated to perform reliably in treating Deterrent Burning Ground groundwater.

continued

TABLE 10-22
DETAILED ANALYSIS - ALTERNATIVE DBG-GW6
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE DBG-GW6 IRM AND UV/REDUCTION
Ease of Undertaking Additional Remedial Actions, if Necessary	This alternative would not preclude or hinder additional remedial actions. The extraction system would not interfere with soil remediation. The groundwater treatment system would be located away from the site and would not interfere with soil remediation.
Ability to Monitor Effectiveness of Remedy	Groundwater quality can be monitored using existing wells. The effectiveness of the treatment system will be monitored through the sampling program established with the Propellant Burning Ground alternative in Subsection 9.4.5.1.
Ability to Obtain Approvals and Coordinate with Other Agencies	No special approvals are anticipated.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Facilities which have sufficient capacity for reactivation of spent carbon are available
Availability of Necessary Equipment and Specialists	Local contractors and materials are available to perform installation and maintenance functions. Contractors are also readily available to provide groundwater transportation services from the Deterrent Burning Ground to the groundwater treatment facility at the Propellant Burning Ground. Availability of UV reduction equipment manufacturers and specialists versed in system design and operation is limited
Availability of Technology	UV reduction technology for the treatment of chlorinated compounds has been developed.
Costs	
Capital Cost	$1,239,000
Present Worth of Operation and Maintenance Cost	$769,000
Net Present Worth Cost	$2,008,000

Table 10-23
Comparative Summary of Remedial Alternatives
Deterrent Burning Ground Groundwater

Feasibility Study
Badger Army Ammunition Plant

Alternative	Overall Protection	Compliance with ARARs	Effectiveness: Long-term	Reduction in Toxicity, Mobility, and Volume	Effectiveness: Short-term	Implementability	Cost
Alternative DBG-GW1: Minimal Action	Possibly protective of human health because institutional controls will prohibit the use of this aquifer as a drinking water source and groundwater monitoring would ensure no contamination has migrated to the regional aquifer. Contaminant concentrations would not be reduced to safe levels until the source area is identified and remediated.	Would not meet chemical-specific ARARs, unless source areas are located and remediated. Location- and action-specific ARARs do not apply.	This alternative would not meet RGs, however residual risk to human health is low.	Contamination is not treated or destroyed; no reduction of toxicity, mobility or volume of contamination.	No adverse impacts to community or environment during implementation.	No implementability concerns.	Total Present Worth: $845,000 Capital Costs: $10,000 Annual O&M Costs: $835,000
Alternative DBG-GW2: IRM and Carbon Adsorption	Possibly protective of human health because contaminant migration of contaminated groundwater to the regional aquifer would be reduced. Contaminant concentrations would not be reduced to safe levels until the source area is identified and remediated.	Would not meet chemical-specific ARARs unless source area is identified and remediated. Location-specific ARARs do not apply. Action-specific ARARs would be attained.	This alternative would not meet RGs, however residual risk to human health is low.	Contaminants are destroyed; reduction of toxicity. Extraction system reduces mobility. Unless source area remediated, no reduction of volume.	Potential for adverse impacts to community or environment when transporting contaminated groundwater.	Significant technical difficulties associated with extraction of groundwater from the elevated aquifer.	Total Present Worth: $2,008,000 Capital Costs: $1,239,000 Annual O&M Costs: $769,000

continued

Table 10-23
Comparative Summary of Remedial Alternatives
Deterrent Burning Ground Groundwater

Feasibility Study
Badger Army Ammunition Plant

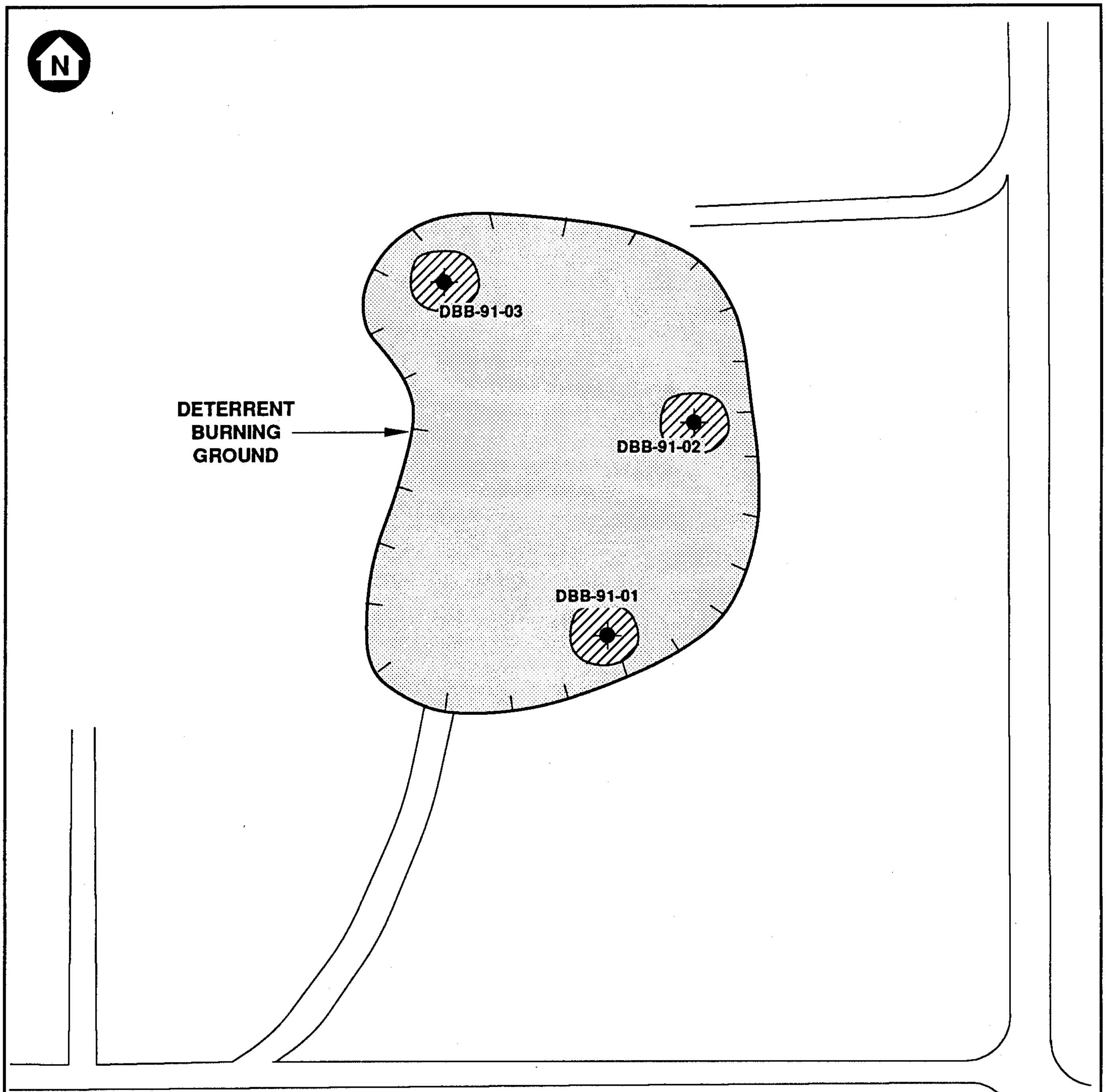
Alternative	Overall Protection	Compliance with ARARs	Effectiveness: Long-Term	Reduction in Toxicity, Mobility, and Volume	Effectiveness: Short-Term	Implementability	Cost
Alternative DBG-GW4: IRM and Air Stripping-Carbon Adsorption	Possibly protective of human health because contaminant migration of contaminated groundwater to the regional aquifer would be reduced. Contaminant concentrations would not be reduced to safe levels until the source area is identified and remediated.	Would not meet chemical-specific ARARs unless source area is identified and remediated. Location-specific ARARs do not apply. Action-specific ARARs would be attained.	This alternative would not meet RGs, however residual risk to human health is low.	Contaminants are destroyed; reduction of toxicity. Extraction system reduces mobility. Unless source area remediated, no reduction of volume.	Potential for adverse impacts to community or environment when transporting contaminated groundwater.	Significant technical difficulties associated with extraction of groundwater from the elevated aquifer.	Total Present Worth: $2,008,000 Capital Costs: $1,239,000 Annual O&M Costs: $769,000
Alternative DBG-GW5: IRM and Resin Adsorption	Possibly protective of human health because contaminant migration of contaminated groundwater to the regional aquifer would be reduced. Contaminant concentrations would not be reduced to safe levels until the source area is identified and remediated.	Would not meet chemical-specific ARARs unless source area is identified and remediated. Location-specific ARARs do not apply. Action-specific ARARs would be attained.	This alternative would not meet RGs, however residual risk to human health is low.	Contaminants are destroyed; reduction of toxicity. Extraction system reduces mobility. Unless source area remediated, no reduction of volume.	Potential for adverse impacts to community or environment when transporting contaminated groundwater.	Significant technical difficulties associated with extraction of groundwater from the elevated aquifer.	Total Present Worth: $2,008,000 Capital Costs: $1,239,000 Annual O&M Costs: $769,000

continued

TABLE 10-23
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
DETERRENT BURNING GROUND GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative DBG-GW6: IRM and UV/Reduction, Carbon Adsorption	Possibly protective of human health because contaminant migration of contaminated groundwater to the regional aquifer would be reduced. Contaminant concentrations would not be reduced to safe levels until the source area is identified and remediated.	Would not meet chemical-specific ARARs unless source area is identified and remediated. Location-specific ARARs do not apply. Action-specific ARARs would be attained.	This alternative would not meet RGs, however residual risk to human health is low.	Contaminants are destroyed; reduction of toxicity. Extraction system reduces mobility. Unless source area remediated, no reduction of volume.	Potential for adverse impacts to community or environment when transporting contaminated groundwater.	Significant technical difficulties associated with extraction of groundwater from the elevated aquifer.	Total Present Worth: $2,008,000 Capital Costs: $1,239,000 Annual O&M Costs: $769,000



LEGEND

APPROXIMATE AREAS OF SUBSURFACE SOIL CONTAMINATION

DBB-91-03 LOCATION AND DESIGNATION OF SOIL BORING

NOTE:
1. PLAN REVISED FROM 300-SCALE SITE PLAN PROVIDED BY OLIN CORPORATION.

SCALE IN FEET

0 120 240

FIGURE 10-1
MINIMAL ACTION ALTERNATIVE
DETERRENT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9305031D 12 4

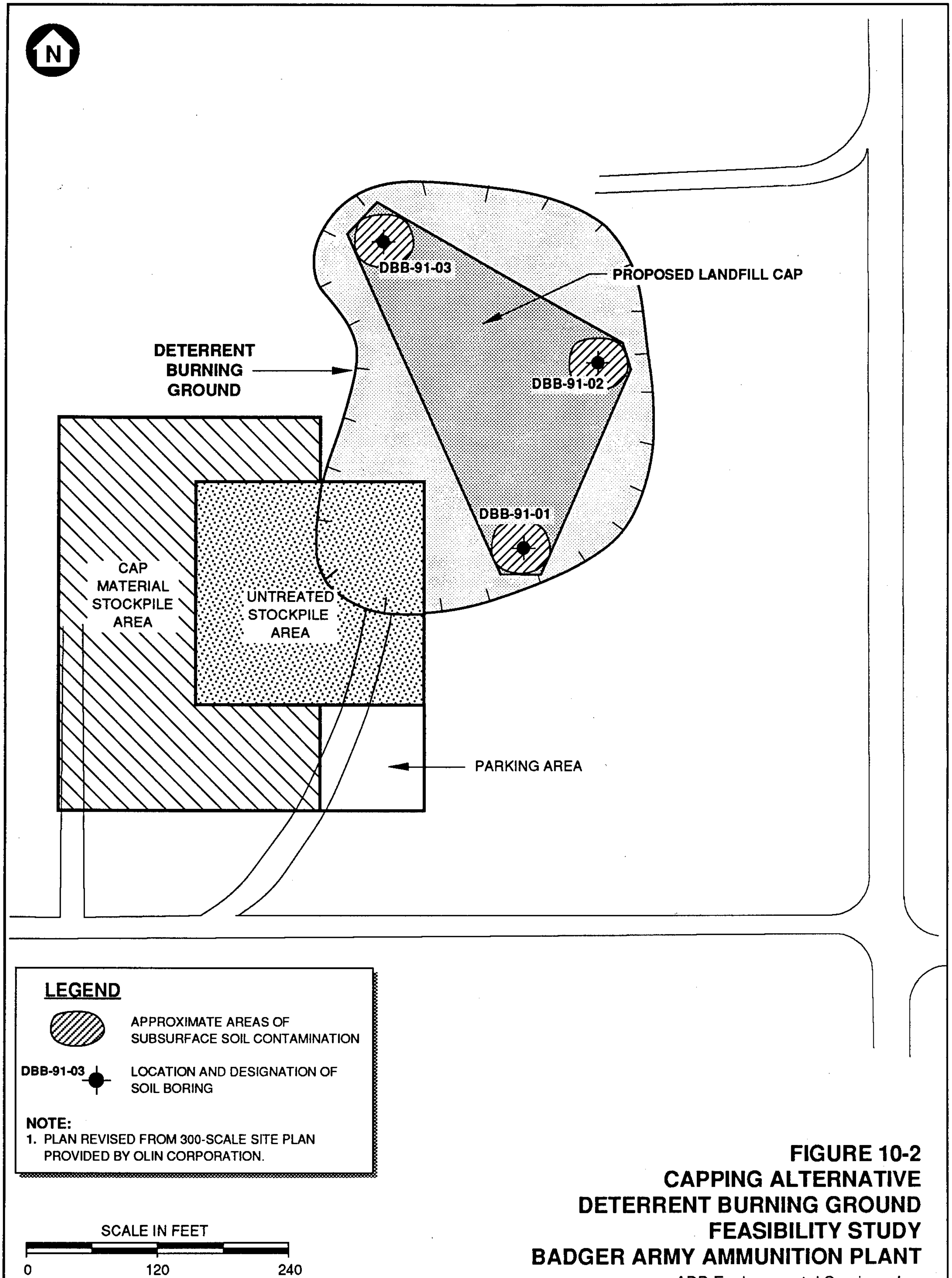


FIGURE 10-2
CAPPING ALTERNATIVE
DETERRENT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407035D(i)12 6 89

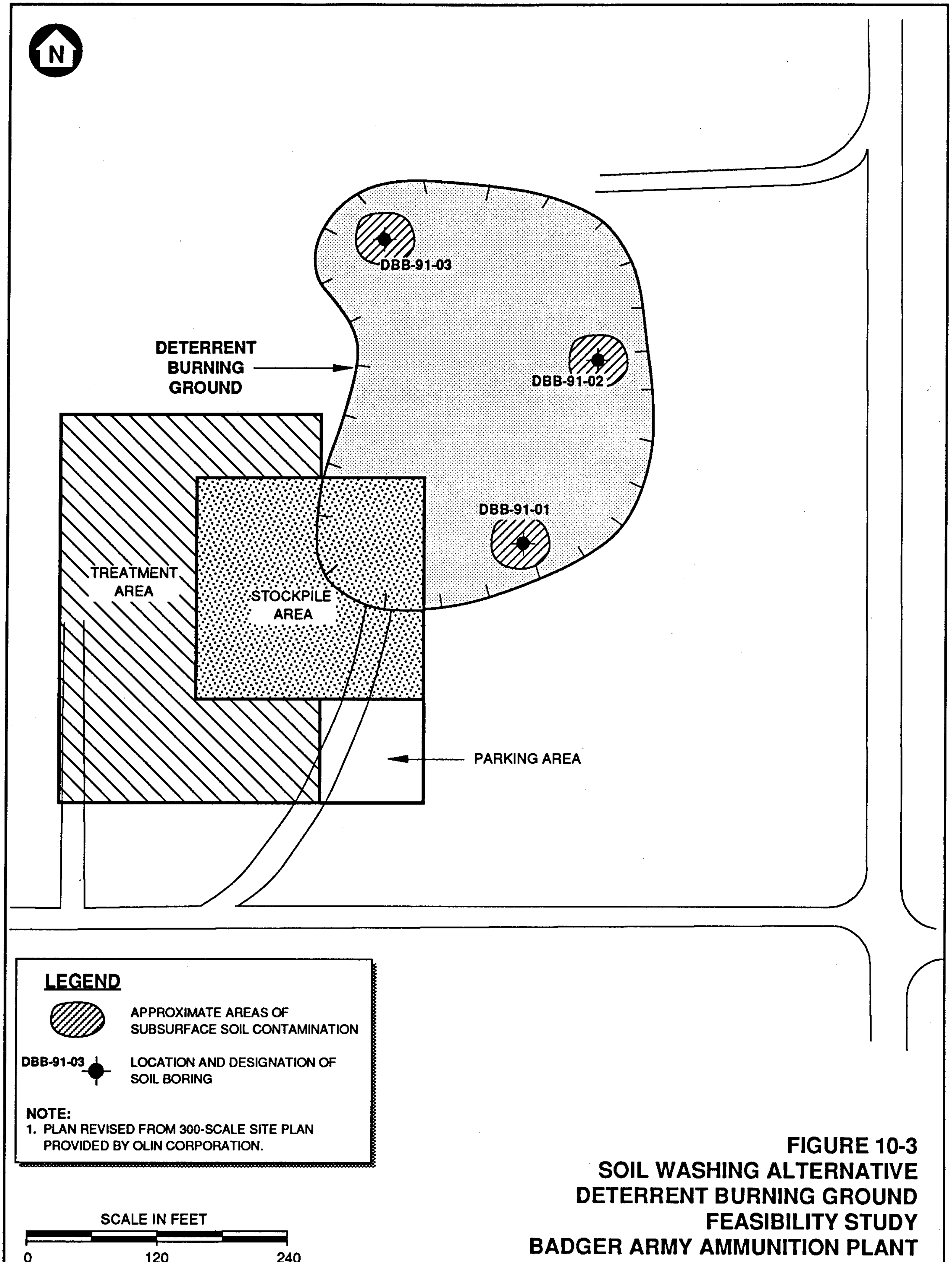
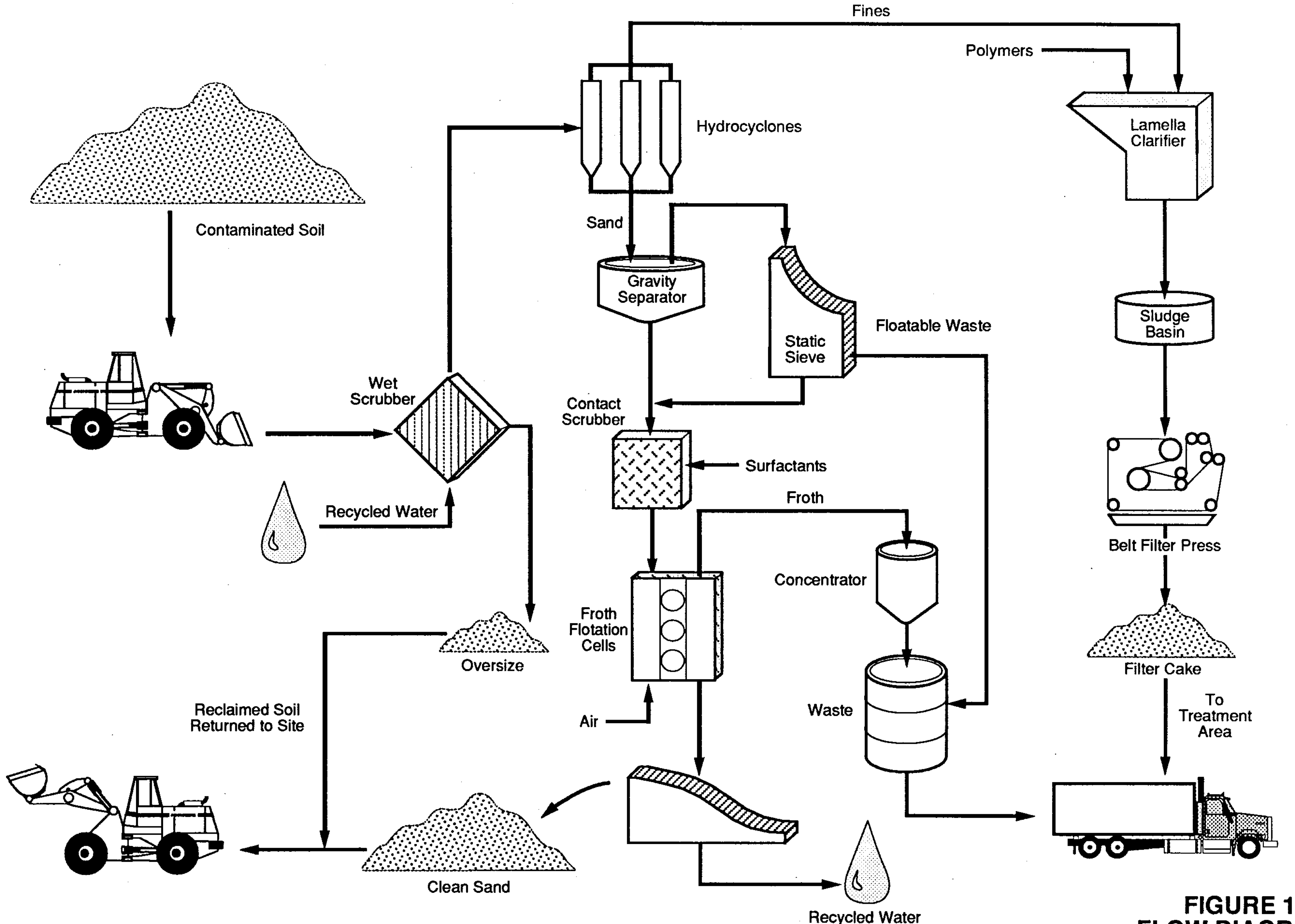


FIGURE 10-3
SOIL WASHING ALTERNATIVE
DETERRENT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407035D(i)12 6

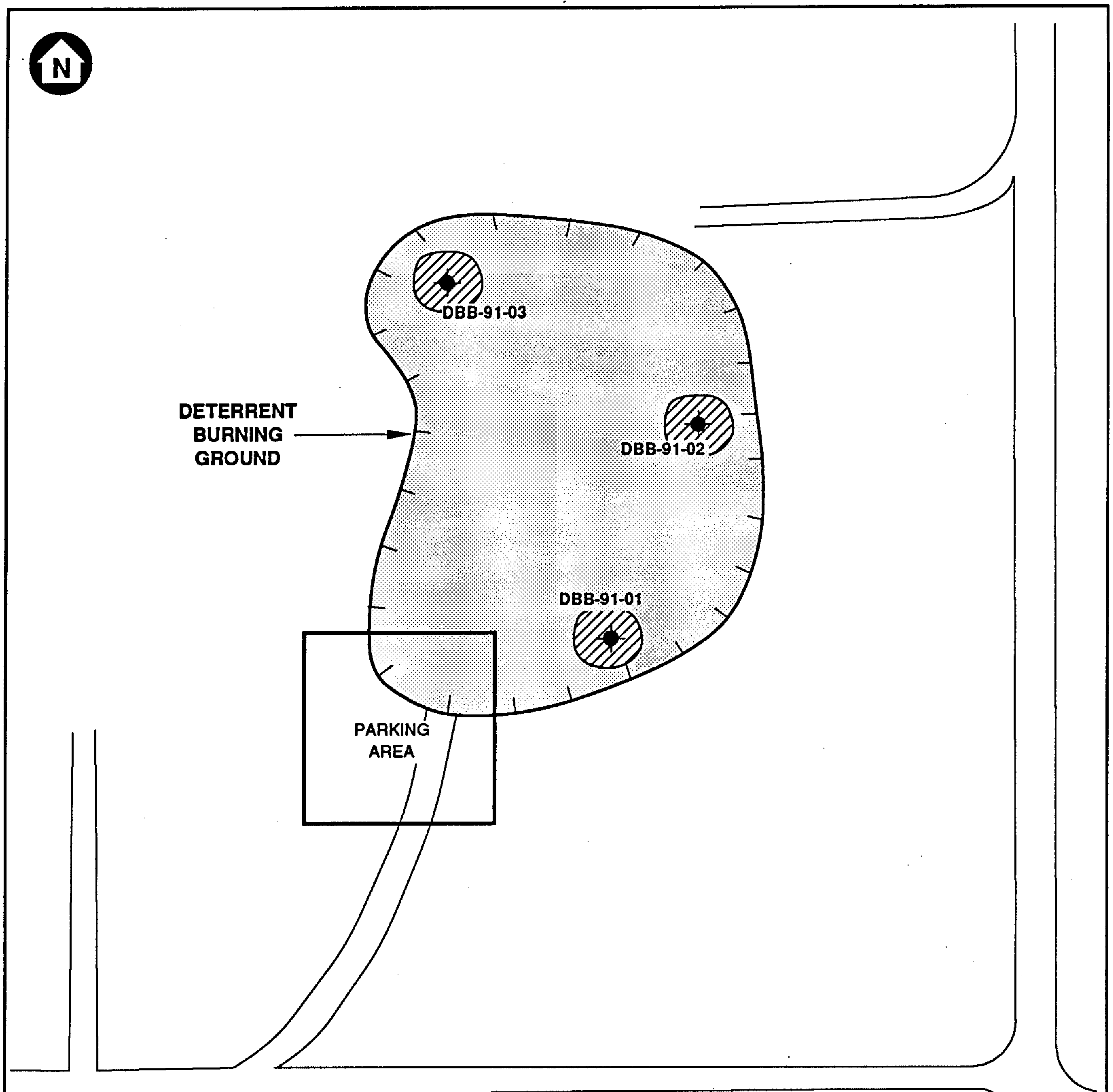


SOURCE:
GERAGHTY & MILLER, INC., AND HEIDEMIJ
RESTSTOFFENDIENSTEN BV. 1992

FIGURE 10-4
FLOW DIAGRAM
SOIL WASHING ALTERNATIVE
DETERRENT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407035D(b)



LEGEND

APPROXIMATE AREAS OF SUBSURFACE SOIL CONTAMINATION

DBB-91-03 LOCATION AND DESIGNATION OF SOIL BORING

NOTE:
1. PLAN REVISED FROM 300-SCALE SITE PLAN PROVIDED BY OLIN CORPORATION.

SCALE IN FEET

0 120 240

FIGURE 10-5
ON-SITE INCINERATION ALTERNATIVE
DETERRENT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407035D(i)12 5

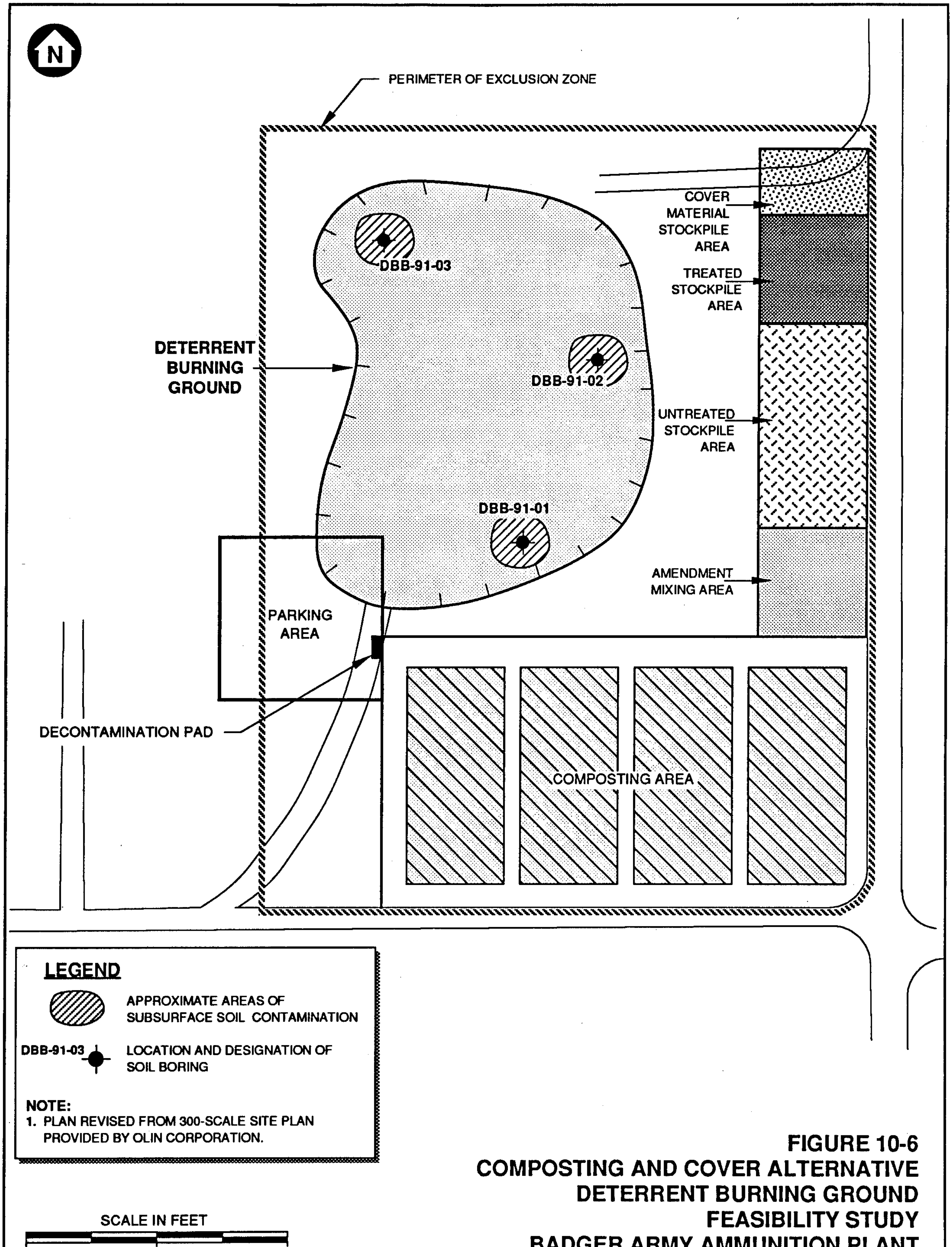


FIGURE 10-6
COMPOSTING AND COVER ALTERNATIVE
DETERRENT BURNING GROUND
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

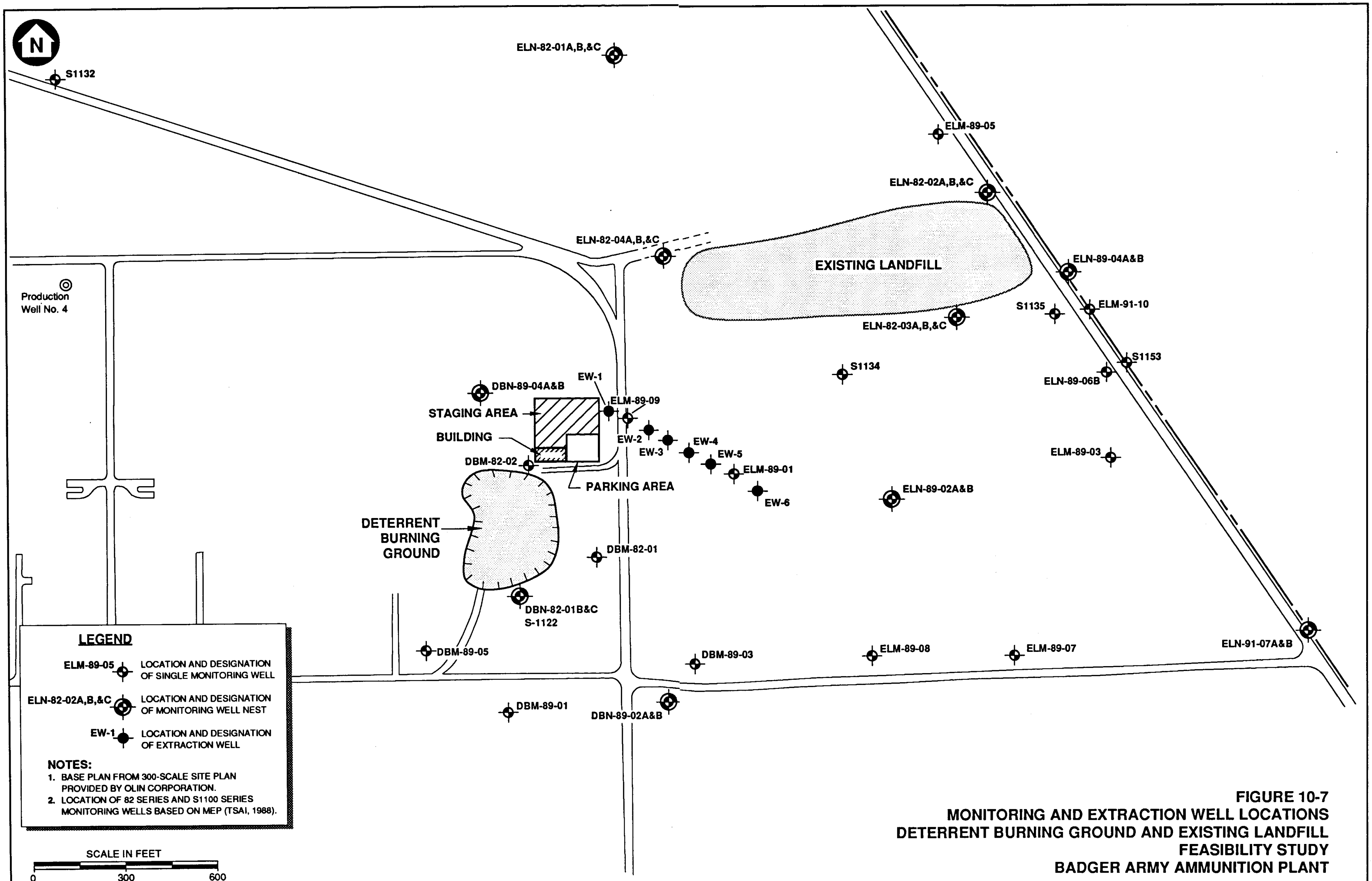


FIGURE 10-7
MONITORING AND EXTRACTION WELL LOCATIONS
DETERRENT BURNING GROUND AND EXISTING LANDFILL
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407035D(a) de u

TABLE 11-1
GROUNDWATER MONITORING PROGRAM
NITROGLYCERINE POND/ROCKET PASTE AREA
SURFACE SOIL AND SEDIMENT ALTERNATIVE NG/RPA-SS1

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GROUNDWATER MONITORING LOCATIONS
S 1124
S 1118
S 1150
RPM 8901
RPM 9101
S 1125
S 1119
NPM 8901
RPM 8902

ANALYTICAL PARAMETERS AND MONITORING FREQUENCY

QUARTERLY	ANNUALLY
pH	VOCs, SVOCs, and Metals (filtered)[1]
Specific Conductance	
Nitrate Nitrogen	

Notes:

1 VOCs, SVOCs, and metals as described in Modification of Conditional Plan Approval of In-Field Conditions Report (WDNR, 1992).

TABLE 11-2
COST SUMMARY TABLE
ALTERNATIVE NP/RPA-SS1: MINIMAL ACTION

FEASIBILITY STUDY
NITROGLYCERINE POND/ROCKET PASTE AREA
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST		
Institutional controls	$	10,000
Fence & Signs		543,000
TOTAL DIRECT COST	**$**	**553,000**
INDIRECT COST		
Health and Safety @ 5% of Total Direct Cost	$	28,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		28,000
Engineering @ 10% of Total Direct Cost		55,000
Services During Construction, QA/QC, Documentation @ 10% of Total Direct Cost		55,000
TOTAL INDIRECT COST	**$**	**166,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**719,000**
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs (Including Groundwater Monitoring)	$	111,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$**	**1,706,000**
TOTAL COST FOR SS-1 MINIMAL ACTION	**$**	**2,425,000**

TABLE 11-3
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS1
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL AND SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS1 MINIMAL ACTION
Overall Protection of Human Health and the Environment	
Human Health Protection	Minimal action would reduce contaminant exposure risks to human receptors by restricting site access.
Environmental Protection	Minimal action eliminates or reduces potential risk to ecological receptors that cannot pass the constructed fence boundary (e.g., deer). The minimal action alternative does not reduce potential risk to ecological receptors such as birds and shrews. Groundwater protection requirements of NR 720 are not met.
Compliance with ARARs	
Chemical-specific	RGs are based on chemical-specific ARARs. The minimal action alternative would not meet interim PB cleanup levels or RGs for NG/RPA surface soil and sediment. Does not meet requirements of NR 720.
Location-specific	Wetlands protection ARARs do not apply to this alternative because no action would be taken.
Action-specific	RCRA hazardous waste units ARARs would be met. Post-closure groundwater monitoring would meet RCRA Releases from SWMU's ARAR.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Under the minimal action alternative, the remaining risk to human receptors would be minimal as long as the fence remains intact. Risk to ecological receptors unaffected by the site fence (e.g., birds, shrews) would remain the same.
Adequacy and Reliability of Controls	If managed properly, the combination of controls (i.e., zoning and deed restrictions, fencing and warning signs) would effectively limit the use of the site by human and many ecological receptors.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	None.
Amount Destroyed or Treated	None.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	Minimal action does not employ removal or treatment processes to address soil contamination at the site.

(continued)

TABLE 11-3
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS1
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL AND SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS1 MINIMAL ACTION
Degree to Which Treatment is Irreversible	Not Applicable.
Type and Quantity of Residuals Remaining After Treatment	Not Applicable.
Short-term Effectiveness	
Protection of Community During Remedial Action	Because this alternative provides only a minimal response action (i.e., installation of fencing and signs), threats to the community are unlikely to be encountered during implementation.
Protection of Workers During Remedial Action	Threats to site-worker health are very unlikely to be encountered during implementation of this alternative. Workers should follow safe working practices.
Environmental Impacts	No environmental impacts are expected during implementation.
Time Until Remedial Action Objectives Are Achieved.	Minimal action does not achieve the remedial response objectives.
Implementability	
Ability to Construct and Operate the Technology	Installing fencing and posting warning signs at the Nitroglycerine Pond and Rocket Paste Area are easily implemented construction tasks.
Reliability of the Technology	If fencing is adequately maintained it should be effective in limiting site access by human and many ecological receptors.
Ease of Undertaking Additional Remedial Actions, if Necessary	Minimal action would not limit or interfere with the ability to perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Annual visual inspections would be sufficient for monitoring minimal action effectiveness.
Ability to Obtain Approvals and Coordinate with Other Agencies	Coordination with appropriate Army officials, WDNR, and the City of Baraboo would be required if these controls are applied. Coordination with Sauk County would be required to implement and maintain a public education program.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Not Applicable.

(continued)

TABLE 11-3
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS1
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL AND SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS1 MINIMAL ACTION
Availability of Necessary Equipment and Specialists	Local contractors and necessary materials are readily available to construct fencing and warning signs as well as to conduct educational programs.
Availability of Technology	Very available.
Costs	
Capital Cost	$719,000
Present Worth of Operation and Maintenance Cost	$1,706,000
Net Present Worth Cost	$2,425,000

TABLE 11-4
COST SUMMARY TABLE
ALTERNATIVE NP/RPA-SS2: SOIL COVER

FEASIBILITY STUDY
NITROGLYCERINE POND/ROCKET PASTE AREA
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST		
Site Preparation and Mob/Demob	$	246,000
Soil Cover Placement		679,000
Rocket Paste Road Culvert		30,000
TOTAL DIRECT COST	**$**	**955,000**
INDIRECT COST		
Health and Safety @ 5% of Total Direct Cost	$	48,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		48,000
Engineering @ 10% of Total Direct Cost		96,000
Services During Construction, QA/QC, Documentation @ 10% of Total Direct Cost		96,000
TOTAL INDIRECT COST	**$**	**288,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**1,243,000**
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs (Including Groundwater Monitoring)	$	114,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$**	**1,752,000**
TOTAL COST FOR SS-2 SOIL COVER	**$**	**2,995,000**

TABLE 11-5
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS2
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS2 SOIL COVER
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objective for human receptors. The soil cover would reduce the potential for human exposure to surface soil and sediment concentrations of lead greater than background. There is no significant risk to human health from other compounds.
Environmental Protection	Achieves the remedial action objective for terrestrial organisms. The soil cover would reduce direct exposure routes for aquatic or terrestrial biota to surface soil/sediment contaminants above RGs which are determined by the ecological receptor risk. Groundwater protection requirements of NR 720 are not met.
Compliance with ARARs	
Chemical-specific	Meets the Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites. Does not meet requirements of NR 720.
Location-specific	Wetlands protection ARARs would be met for remediation of the ponds because no practicable alternative less harmful to the wetlands is available to meet RGs. The USFWS, NMFS, and other related agencies must be consulted before modifying the ponds. A permit may be required from the U.S. Army Corps of Engineers.
Action-specific	RCRA hazardous waste units ARARs would be met. Post-closure groundwater monitoring would meet RCRA Releases from SWMU's ARAR. Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). Dust suppression techniques and other preventative measures used where necessary would ensure compliance with particulate emission standards. RCRA Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR - Part 264) may apply. If applicable, a program which incorporates the standards would be implemented.
Other Criteria, Advisories, and Guidances	None.

(continued)

TABLE 11-5
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS2
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS2 SOIL COVER
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Provided the soil covers remain intact, residual risk to human and ecological receptors would be negligible. RI data indicates that metals in NG/RPA surface soil/sediment are not mobile (ABB-ES, 1993a); consequently, there is no expected threat of groundwater contamination from leaching. A threat to groundwater quality exists because the requirements of NR 720 are not met.
Adequacy and Reliability of Controls	Visual inspections would be conducted annually to ensure the integrity of the soil covers. Long-term groundwater monitoring would detect contaminants leaching into groundwater.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	None.
Amount Destroyed or Treated	None.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	No reduction in the toxicity, mobility, or volume of contaminants. However, natural mobilizing influences such as soil erosion would be reduced.
Degree to Which Treatment is Irreversible	Not applicable.
Type and Quantity of Residuals Remaining After Treatment	Not applicable.
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation.
Protection of Workers During Remedial Action	With the use of dust suppression techniques and adherence to general health and safety practices, there would be minimal risk to workers as no excavation of contaminated material would occur.
Environmental Impacts	The Rocket Paste Area is not considered critical wildlife habitat. Waterfowl using the Nitroglycerine Pond would be disturbed by implementation of the alternative.
Time Until Remedial Action Objectives Are Achieved	An estimated 10 to 12 months would be required to achieve the remedial action objectives from the start of remediation (because the surface water must be removed and treated prior to placement of the soil cover on the sediment).

(continued)

TABLE 11-5
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS2
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS2 SOIL COVER
Implementability	
Ability to Construct and Operate the Technology	Cover construction can be accomplished using standard construction procedures and conventional earth-moving equipment. Cover repairs would be easily implementable.
Reliability of the Technology	Soil cover is a proven technology for isolating potential receptors from contaminated soil. Annual visual inspections and soil cover repair (if necessary) would ensure that the integrity of the soil cover is maintained.
Ease of Undertaking Additional Remedial Actions, if Necessary	The soil cover would increase the scope of any future removal actions requiring access to the contaminated soil/sediment. Capping, though, could be easily constructed over the soil cover.
Ability to Monitor Effectiveness of Remedy	Annual visual inspections would be sufficient for monitoring soil cover effectiveness.
Ability to Obtain Approvals and Coordinate with Other Agencies	The integrity of the remedial design would have to be demonstrated to federal and state regulators. A wetland permit may be required from the U.S. Army Corps of Engineers for remediation at the Nitroglycerine Pond, overflow, and Rocket Paste Ponds.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Not applicable.
Availability of Necessary Equipment and Specialists	Obtaining sufficient common borrow soil and vegetative soil in the immediate vicinity of BAAP should not be difficult; materials may be available within 30 miles of BAAP. A large excavation contracting company could easily provide the equipment and expertise for constructing soil covers.
Availability of Technology	Several vendors would be available to provide the technology involved in installing a soil cover.
Costs	
Capital Cost	$1,243,000
Present Worth of Operation and Maintenance Cost	$1,752,000
Net Present Worth Cost	$2,995,000

TABLE 11-6
COST SUMMARY TABLE
ALTERNATIVE NP/RPA-SS3: STABILIZATION/SOLIDIFICATION WITH ON-SITE DISPOSAL

FEASIBILITY STUDY
NITROGLYCERINE POND/ROCKET PASTE AREA
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST		
Treatability Testing	$	96,000
Site Preparation and Mob/Demob		588,000
Contaminated Soil Delineation		123,000
Sediment Removal		335,000
Excavate Surface Soil		676,000
Backfill Soil		743,000
Stabilization/Solidification		6,090,000
Confirmation Sampling		219,000
Load Soil/Sediment into Treatment Equipment		89,000
Load/Haul Treated Soil/Sediment to Race Track and Spread		425,000
Rocket Paste Road Culvert		30,000
Additional Cover Required at PBG		516,000
TOTAL DIRECT COST	$	9,930,000
INDIRECT COST		
Health and Safety @ 5% of Total Direct Cost	$	497,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		497,000
Engineering @ 10% of Total Direct Cost		993,000
Services During Construction, QA/QC, Documentation @ 10% of Total Direct Cost		993,000
TOTAL INDIRECT COST	$	2,980,000
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$	12,910,000
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs (Long-term performance monitoring included with PBG)	$	0
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	$	0
TOTAL COST FOR SS-3 STABILIZATION/SOLIDIFICATION WITH ON-SITE DISPOSAL	$	12,910,000

TABLE 11-7
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS3
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS3 EXCAVATION/S-S/ON-SITE DISPOSAL
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objective for human receptors. Contaminated soil is removed from NG/RPA.
Environmental Protection	Achieves the remedial action objective for terrestrial organisms. Contaminated soil is removed from NG/RPA. Excavation and treatment would reduce direct exposure routes for aquatic or terrestrial biota to surface soil/sediment contaminants above RGs which are determined by ecological receptor risk. Would protect groundwater quality consistent with NR 720.
Compliance with ARARs	
Chemical-specific	Meets the Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites.
Location-specific	Wetlands protection ARARs would be met for remediation of the ponds because no practicable alternative less harmful to the wetlands is available to meet RGs. The USFWS, NMFS, and other related agencies must be consulted before modifying the ponds. A permit may be required from the U.S. Army Corps of Engineers.
Action-specific	RCRA hazardous waste units ARARs would be met. Because soils would undergo placement, RCRA Land Disposal Regulations (LDRs) may apply. Confirmatory sampling after treatment would assist in determining LDR compliance. Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). Dust suppression techniques and other preventative measures used where necessary would ensure compliance with particulate emission standards. RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR - Part 264) may apply. If applicable, a program which incorporates the standards would be implemented.

(continued)

TABLE 11-7
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS3
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS3 EXCAVATION/S-S/ON-SITE DISPOSAL
Other Criteria, Advisories, and Guidances	None.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Excavation is expected to remove a majority of surface soil/sediment contamination; contamination delineation sampling would ensure removal of all contamination. Residual risk to human, ecological receptors, and groundwater at the NG/RPA would be negligible. Provided the treated soil/sediment and the on-site disposal cover remains intact, residual risk to human and ecological receptors from the treated soil/sediment would be negligible. Metals would not likely leach from the treated soil/sediment. Consequently, the threat of groundwater contamination from leaching is virtually eliminated.
Adequacy and Reliability of Controls	Visual inspections would be conducted annually to ensure the integrity of the cover for the buried solidified material. Long-term groundwater sampling and analysis at the disposal area would allow monitoring of groundwater quality.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Stabilization/solidification treatment would be used to chemically and physically bind the surface soil and sediment contaminants into a granular or monolithic product with a low leaching potential.
Amount Destroyed or Treated	An estimated 73,000 cubic yards of excavated surface soil/sediment would be treated.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	No reduction in toxicity is expected. Mobility would be greatly reduced as the contaminants would be stabilized and solidified in the treated product. The volume of treated soil/sediment can be expected to have increased by about 20 to 30 percent because of the additives, though the actual amount of contamination would not increase.
Degree to Which Treatment is Irreversible	Proper maintenance would prevent weathering of the cover and treatment residuals and the subsequent release of contaminants.
Type and Quantity of Residuals Remaining After Treatment	Treatment residuals would consist of pelletized/granular material disposed of at PBG. Assuming the volume of the contaminated soil increased by 30 percent during treatment, approximately 95,000 cubic yards of residuals would be disposed of at the race track area of the Propellant Burning Ground.

(continued)

TABLE 11-7
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS3
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS3 EXCAVATION/S-S/ON-SITE DISPOSAL
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation.
Protection of Workers During Remedial Action	With the use of dust suppression techniques and adherence to general health and safety practices, there would be minimal risk to workers. As excavation of contaminated surface soil/sediment occurs, proper health monitoring would be implemented and decontamination procedures followed.
Environmental Impacts	The Rocket Paste Area is not considered critical wildlife habitat. Waterfowl using the Nitroglycerine Pond would be disturbed during implementation of the alternative.
Time Until Remedial Action Objectives Are Achieved	An estimated 5 to 6 months would be required to achieve the remedial action objectives from the start of remediation (because the surface water must be removed and treated prior to remediating pond sediments).
Implementability	
Ability to Construct and Operate the Technology	Excavation and backfilling can be accomplished using standard construction procedures and conventional earthmoving equipment. Stabilization/solidification is a relatively simple, easily implemented technology.
Reliability of the Technology	Stabilization/solidification is a proven technology for isolating potential receptors from contaminated soil. It has been demonstrated full-scale at numerous sites. S/S treatment is highly dependent on site and waste characteristics. Extensive treatability testing would be required.
Ease of Undertaking Additional Remedial Actions, if Necessary	If necessary, the treated material could be removed from the on-site disposal site and placed in a different location or re-treated, though this would involve a significant level of effort because of the large quantities involved. Capping, though, could be easily constructed over the treated material.
Ability to Monitor Effectiveness of Remedy	The contamination would be removed from the NG/RPA. Annual visual inspections of the on-site disposal location for the treated material would be sufficient for monitoring the effectiveness.
Ability to Obtain Approvals and Coordinate with Other Agencies	The integrity of the remedial design would have to be demonstrated to federal and state regulators. A wetland permit may be required from the U.S. Army Corps of Engineers. If soils are determined to be characteristically hazardous (per RCRA), a RCRA permit may be needed prior to treatment.

(continued)

TABLE 11-7
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS3
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS3 EXCAVATION/S-S/ON-SITE DISPOSAL
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Not applicable.
Availability of Necessary Equipment and Specialists	Obtaining sufficient common borrow soil and vegetative soil in the immediate vicinity of BAAP should not be difficult; materials may be available within 30 miles of BAAP. A large excavation contracting company could easily provide the equipment and expertise for conducting excavation and backfilling.
Availability of Technology	Several vendors would be available to provide the technology involved for excavation, stabilization/ solidification, and on-site disposal.
Costs	
Capital Cost	$12,910,000
Present Worth of Operation and Maintenance Cost	$0
Net Present Worth Cost	$12,910,000

TABLE 11-8
COST SUMMARY TABLE
ALTERNATIVE NP/RPA-SS4: OFF-SITE DISPOSAL

FEASIBILITY STUDY
NITROGLYCERINE POND/ROCKET PASTE AREA
BADGER ARMY AMMUNITION PLANT

ITEM	TOTAL COST
DIRECT COST	
Site Preparation and Mob/Demob	$ 527,000
Contaminated Soil Delineation	123,000
Sediment Removal	447,000
Excavate Surface Soil	651,000
Backfill Soil	877,000
Off-site Disposal	24,070,000
Rocket Paste Road Culvert	30,000
TOTAL DIRECT COST	**$ 26,725,000**
INDIRECT COST	
Health and Safety @ 5% of Total Direct Cost	$ 1,336,000
Legal, Administration, Permitting @ 5% of Total Direct Cost	1,336,000
Engineering @ 10% of Total Direct Cost	2,673,000
Services During Construction, QA/QC, Documentation @ 10% of Total Direct Cost	2,673,000
TOTAL INDIRECT COST	**$ 8,018,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$ 34,743,000**
OPERATING AND MAINTENANCE COSTS	
Total Annual Operating and Maintenance Costs	$ 0
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$ 0**
TOTAL COST FOR SS-4 OFF-SITE DISPOSAL	**$ 34,743,000**

TABLE 11-9
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS4
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS4 EXCAVATION/OFF-SITE DISPOSAL
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objective for human receptors.
Environmental Protection	Achieves the remedial action objective for terrestrial organisms. Excavation and off-site disposal would eliminate direct exposure routes for aquatic or terrestrial biota to surface soil/sediment contaminants above RGs which have been determined by ecological receptor risk. Groundwater quality requirements of NR 720 would be met.
Compliance with ARARs	
Chemical-specific	Meets the Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites.
Location-specific	Wetlands protection ARARs would be met for remediation of the ponds because no practicable alternative less harmful to the wetlands is available to meet the RGs. The USFWS, NMFS, and other related agencies must be consulted before modifying the ponds. A permit may be required from the U.S. Army Corps of Engineers.
Action-specific	RCRA hazardous waste units ARARs would be met. Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). Dust suppression techniques and other preventative measures used where necessary would ensure compliance with particulate emission standards. RCRA Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR - Part 264) may apply. If applicable, a program which incorporates the standards would be implemented. Excavated soil/sediment would be tested for TCLP to determine its status as a hazardous or non-hazardous waste. Transportation of excavated soil/sediment would be performed in accordance with RCRA waste piles, transportation, disposal facility standards, landfill, manifest, and LDR ARARs.
Other Criteria, Advisories, and Guidances	None.

(continued)

TABLE 11-9
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS4
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS4 EXCAVATION/OFF-SITE DISPOSAL
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Excavation would be expected to remove surface soil/sediment contamination; contamination delineation sampling would ensure removal of all contamination. Residual risk to human and ecological receptors at the NG/RPA would be negligible. Groundwater quality requirements of NR 720 would be met. Residual risk to human and ecological receptors from the soil/sediment would be negligible at a licensed off-site disposal facility.
Adequacy and Reliability of Controls	None required.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Treatment is not a principal element of this alternative; however, soil exhibiting the toxicity characteristics would be stabilized at the TSDF.
Amount Destroyed or Treated	Uncertain, depending on TCLP results.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	No reduction in toxicity is expected. Mobility would be greatly reduced as the contaminants will be placed in a permitted off-site disposal facility. The volume of sediments may be increased if absorbent material is added prior to transportation.
Degree to Which Treatment is Irreversible	Not applicable.
Type and Quantity of Residuals Remaining After Treatment	Not applicable.
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during excavation. There is a minimal risk to the public during the transportation of the contaminated surface soil/sediment over public roadways to the off-site disposal facility.
Protection of Workers During Remedial Action	With the use of dust suppression techniques and adherence to general health and safety practices, there would be minimal risk to workers. As excavation of contaminated surface soil/sediment occurs, proper health monitoring would be implemented and proper decontamination procedures followed.
Environmental Impacts	The Rocket Paste Area is not considered critical wildlife habitat. Waterfowl using the Nitroglycerine Pond would be disturbed during implementation of the alternative.

(continued)

TABLE 11-9
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS4
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS4 EXCAVATION/OFF-SITE DISPOSAL
Time Until Remedial Action Objectives Are Achieved	An estimated 10 to 12 months would be required to achieve the remedial action objectives from the start of remediation (because the surface water must be removed and treated prior to remediating pond sediments).
Implementability	
Ability to Construct and Operate the Technology	Excavation and backfilling can be accomplished using standard construction procedures and conventional earth-moving equipment. Transportation and off-site disposal is easily implemented.
Reliability of the Technology	Off-site disposal at a permitted facility is a reliable, proven method for disposing contaminated wastes.
Ease of Undertaking Remedial Actions, if Necessary	If further remediation is deemed necessary, the backfill soil cover will require removal.
Ability to Monitor Effectiveness of Remedy	The contamination would be removed from the NG/RPA. Long-term monitoring and maintenance provided by the off-site landfill facility.
Ability to Obtain Approvals and Coordinate with Other Agencies	The integrity of the remedial design would have to be demonstrated to federal and state regulators. A wetland permit may be required from the U.S. Army Corps of Engineers for remediation at the Nitroglycerine Pond. RCRA hazardous waste permit potentially required.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Off-Site disposal capacity available.
Availability of Necessary Equipment and Specialists	Obtaining sufficient common borrow soil and topsoil in the immediate vicinity of BAAP should not be difficult; materials may be available within 30 miles of BAAP. A large excavation contracting company could easily provide the equipment and expertise for conducting excavation and backfilling.
Availability of Technology	Several vendors would be available to provide the technology involved for excavation and off-site disposal.
Costs	
Capital Cost	$34,743,000
Present Worth of Operation and Maintenance Cost	$0
Net Present Worth Cost	$34,743,000

TABLE 11-10
COST SUMMARY TABLE
ALTERNATIVE NP/RPA-SS5: IN-SITU STABILIZATION/SOLIDIFICATION WITH SOIL COVER

FEASIBILITY STUDY
NITROGLYCERINE POND/ROCKET PASTE AREA
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST		
Treatability Testing	$	96,000
Site Preparation and Mob/Demob		516,000
Contaminated Soil Delineation		123,000
Rocket Paste Road Culvert		30,000
Stabilization/Solidification		3,255,000
Confirmation Sampling		219,000
Soil Cover Construction		1,287,000
TOTAL DIRECT COST	**$**	**5,526,000**
INDIRECT COST		
Health and Safety @ 5% of Total Direct Cost	$	276,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		276,000
Engineering @ 10% of Total Direct Cost		553,000
Services During Construction, QA/QC, Documentation @ 10% of Total Direct Cost		553,000
TOTAL INDIRECT COST	**$**	**1,658,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**7,184,000**
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs (Including Groundwater Monitoring)	$	144,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$**	**2,214,000**
TOTAL COST FOR SS-5 IN-SITU STABILIZATION/SOLIDIFICATION WITH SOIL COVER	**$**	**9,398,000**

TABLE 11-11
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS5
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS5 IN-SITU/S-S/SOIL COVER
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objective for human receptors.
Environmental Protection	Achieves the remedial action objective for terrestrial organisms. Treatment and cover would reduce direct exposure routes for aquatic or terrestrial biota to surface soil/sediment contaminants above RGs which are determined by ecological receptor risk. Would protect groundwater quality consistent with NR 720.
Compliance with ARARs	
Chemical-specific	Meets the Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites.
Location-specific	Wetlands protection ARARs would be met for remediation of the ponds because no practicable alternative less harmful to the wetlands is available to meet RGs. The USFWS, NMFS, and other related agencies must be consulted before modifying the ponds. A permit may be required from the U.S. Army Corps of Engineers.
Action-specific	RCRA hazardous waste units ARARs would be met. Post-closure groundwater monitoring would meet RCRA Releases from SWMU's ARAR. Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). Dust suppression techniques and other preventative measures used where necessary would ensure compliance with particulate emission standards. RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR - Part 264) may apply. If applicable, a program which incorporates the standards would be implemented.
Other Criteria, Advisories, and Guidances	None.

(continued)

TABLE 11-11
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS5
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS5 IN-SITU/S-S/SOIL COVER
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Contamination delineation sampling would determine the extent of treatment. Backfilling with a soil cover would greatly reduce potential human and ecological receptor exposure to the treated soil/sediment. Residual risk to human and ecological receptors at the NG/RPA would be negligible. RI data indicates that metals in NG/RPA soil/sediment are not mobile (ABB-ES, 1993a). Consequently, there is no expected threat of groundwater contamination from leaching of any remaining contamination. Provided the treated soil/sediment and the on-site disposal cover remain intact, residual risk to human and ecological receptors from the treated soil/sediment would be negligible. Metals would not likely leach from the treated soil/sediment. Consequently, the threat of groundwater contamination from leaching is virtually eliminated.
Adequacy and Reliability of Controls	Visual inspections would be conducted annually to ensure the integrity of the cover for the buried solidified material. Long-term groundwater monitoring at the NG/RPA area would detect soil contaminants leaching into groundwater.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Stabilization/solidification treatment would be used to chemically and physically bind the surface soil and sediment contaminants into a granular or monolithic product with a low leaching potential.
Amount Destroyed or Treated	An estimated 73,000 cubic yards of surface soil/sediment would be treated.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	No reduction in toxicity is expected. Mobility would be greatly reduced as the contaminants would be stabilized and solidified in the treated mass. The volume of treated soil/sediment can be expected to have increased by about 20 to 30 percent because of the additives, though the actual amount of contamination would not increase. The backfilled soil cover will reduce potential for human and ecological contact with the treated soil/sediment.
Degree to Which Treatment is Irreversible	Treatment is potentially reversible, however, proper cover maintenance would prevent weathering of the treatment residuals and the subsequent release of contaminants.
Type and Quantity of Residuals Remaining After Treatment	Treatment residuals would consist of pelletized/granular material over the area of the ditches. Assuming the volume of the contaminated soil increased by 30 percent during treatment, approximately 95,000 cubic yards of contaminated soil would be treated in place.

(continued)

TABLE 11-11
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS5
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS5 IN-SITU/S-S/SOIL COVER
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation.
Protection of Workers During Remedial Action	With the use of dust suppression techniques and adherence to general health and safety practices, there would be minimal risk to workers. As treatment of contaminated surface soil/sediment occurs, proper health monitoring would be implemented and decontamination procedures followed.
Environmental Impacts	The Rocket Paste Area is not considered critical wildlife habitat. Waterfowl using the Nitroglycerine Pond would be disturbed during implementation of the alternative.
Time Until Remedial Action Objectives Are Achieved	An estimated 4 to 6 months would be required to achieve the remedial action objectives from the start of remediation (because the surface water must be removed and treated prior to remediating pond sediments).
Implementability	
Ability to Construct and Operate the Technology	A soil cover can be accomplished using standard construction procedures and conventional earth-moving equipment. Stabilization/solidification is a relatively simple, easily implemented technology.
Reliability of the Technology	Stabilization/solidification is a proven technology for isolating potential receptors from contaminated soil. It has been demonstrated full-scale at numerous sites. However, success of S/S treatment is highly dependent on site and waste characteristics. Extensive treatability testing would be required.
Ease of Undertaking Additional Remedial Actions, if Necessary	If necessary, the treated material could be excavated and placed in a different location or re-treated, though this would involve a significant level of effort because of the large quantities involved.
Ability to Monitor Effectiveness of Remedy	Annual visual inspections of the soil cover over the treated material would be sufficient for monitoring the effectiveness.
Ability to Obtain Approvals and Coordinate with Other Agencies	The integrity of the remedial design would have to be demonstrated to federal and state regulators. A wetland permit may be required from the U.S. Army Corps of Engineers for remediation of the nitroglycerine, overflow, and Rocket Paste Ponds.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Not applicable.

(continued)

TABLE 11-11
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SS5
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SS5 IN-SITU/S-S/SOIL COVER
Availability of Necessary Equipment and Specialists	Obtaining sufficient common borrow soil and vegetative soil in the immediate vicinity of BAAP should not be difficult; materials may be available within 30 miles of BAAP. A large excavation contracting company could easily provide the equipment and expertise for conducting excavation and backfilling.
Availability of Technology	Several vendors would be available to provide the technology involved for in situ stabilization.
Costs	
Capital Cost	$7,184,000
Present Worth of Operation and Maintenance Cost	$2,214,000
Net Present Worth Cost	$9,398,000

TABLE 11-12
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION OF MOBILITY, TOXICITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
NG/RPA-SS1: Minimal Action	Reduces risks to humans and some ecological receptors (e.g., deer) by restricting access to the NG/RPA area. Does not meet groundwater quality requirements of NR 720.	Would not meet chemical-specific ARARs. Location- and action-specific ARARs do not apply.	Not applicable because remedial action objectives are not achieved.	Contamination is not treated or destroyed; no reduction of toxicity, mobility or volume of contaminants.	Minimal impact to community or workers during implementation.	Very easily implemented.	Total Present Worth: $2,425,000 Capital Cost: $719,000 Annual O&M: $111,000
NG/RPA-SS2: Soil Cover	Meets remedial action objectives by reducing exposure risks to human and ecological receptors by reducing exposure to surface soil/sediment. Does not meet groundwater quality requirements of NR 720.	Would not meet chemical-specific ARARs. Location-specific ARARs for wetlands apply. Action-specific ARARs would be attained.	If properly maintained, will effectively prevent exposure of human and ecological receptors. Does not provide long-term protection of groundwater.	Contamination is not treated or destroyed; no reduction of toxicity, mobility or volume of contaminants.	Using dust depression techniques and general health and safety practices would result in minimal risks to workers. Minimal impact on community during implementation. Impact on waterfowl at the NG Pond during implementation.	Cover system easily installed.	Total Present Worth: $2,995,000 Capital Cost: $1,243,000 Annual O&M: $114,000
NG/RPA-SS3: Excavation/ Solidification/ On-site Disposal	Eliminates exposure risks to human and ecological receptors at the NG/RPA by removing contaminated surface soil/sediment. Contaminated soil/ sediment would, though, remain at BAAP. Groundwater quality requirements of NR 720 are met.	Would meet chemical-specific ARARs. Location-specific ARARs would apply. Action-specific ARARs would be attained.	Would be capable of maintaining protection at the NG/RPA because the contaminated soil would have been removed. Effective at the on-site disposal location as long as the location remains secure.	No reduction in toxicity. Stabilization/solidification would greatly reduce mobility. Volume of soil would increase by 20-30% (though not increasing actional amount of contamination).	Same as for NG/RPA-SS2 except excavation of contamination would increase risks to workers.	Excavation easily performed. Stabilization/solidification technology easily implemented.	Total Present Worth: $12,910,000 Capital Cost: $12,910,000 Annual O&M: $0

(continued)

TABLE 11-12
COMPARATIVE SUMMARY OF REMEDIAL ALTERNATIVES
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE SOIL/SEDIMENT

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION OF MOBILITY, TOXICITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
NG/RPA-SS4: Excavation/Off-site Disposal	Eliminates exposure risks to human and ecological receptors at the NG/RPA by removing contaminated surface soil/sediment. Groundwater quality requirements of NR 720 are met.	Would meet chemical-specific ARARs. Location-specific ARARs would apply. Action-specific ARARs would be attained.	Would be capable of maintaining protection at the NG/RPA because the contaminated soil would have been removed. Effective at the off-site disposal facility as long as the facility is maintained.	No reduction in toxicity or volume. Mobility would be greatly reduced as contaminated surface soil/sediment would be placed in a permitted off-site disposal facility.	Same as for NG/RPA-SS2 except excavation of contamination would increase risks to workers.	Excavation easily performed. Transportation and off-site disposal easily implemented.	Total Present Worth: $34,743,000 Capital Cost: $34,743,000 Annual O&M: $0
NG/RPA-SS5: In-Situ Solidification/ Soil Cover	Achieves remedial action objectives for human and ecological receptors. Ground-water requirements of NR 720 are met.	Would meet chemi-cal-specific ARARs. Location-specific ARARs would apply, action-specific ARARs would be met.	Would be capable of maintaining protec-tion of NG/RPA as long as treated soil/ sediment and the soil cover remain intact.	No reduction in toxicity. Stabilization/solidifi-cation would greatly reduce mobility. Volume of soil would increase by 20% to 30% (though not increasing actual amount of contamination.	Same as for NG/RPA-SS2.	Stabilization/solidifi-cation technology easily implemented. Cover system easily installed.	Total Present Worth: $9,398,000 Capital Cost: $7,184,000 Annual O&M: $144,000

Notes:

RG = Remediation Goal
ARARs = Applicable or Relevant and Appropriate Requirements

TABLE 11–13
COST SUMMARY TABLE
ALTERNATIVE NP/RPA–SW1: MINIMAL ACTION

FEASIBILITY STUDY
NITROGLYCERINE POND/ROCKET PASTE AREA
BADGER ARMY AMMUNITION AREA

ITEM		TOTAL COST
DIRECT COST		
Institutional Controls	$	10,000
Fencing & Warning Signs		96,000
TOTAL DIRECT COST	**$**	**106,000**
INDIRECT COST		
Health and Safety @ 5% of Total Direct Cost	$	5,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		5,000
Engineering @ 10% of Total Direct Cost		11,000
Services During Construction, QA/QC, Documentation @ 10% of Total Direct Cost		11,000
TOTAL INDIRECT COST	**$**	**32,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**138,000**
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	13,000
Total Present Worth of Annual O&M Costs (5% for Thirty Years)		200,000
Annual Groundwater Sampling – First four years		3,000
Total Present Worth of Annual GW Sampling (5% for Four Years)		11,000
TOTAL PRESENT WORTH OF O&M COSTS	**$**	**211,000**
TOTAL COST FOR SW–1 MINIMAL ACTION	**$**	**349,000**

TABLE 11-14
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SW1
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE WATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SW1 MINIMAL ACTION
Overall Protection of Human Health and the Environment	
Human Health Protection	There are no unacceptable excess human health risks posed by chemicals in surface water at the NG/RPA ponds.
Environmental Protection	Minimal action does not eliminate or reduce potential risk to several ecological receptors posed by the surface water at the Nitroglycerine, Overflow, and Rocket Paste Ponds.
Compliance with ARARs	
Chemical-specific	RGs are based on chemical-specific ARARs. The minimal action alternative does not meet the RGs for ecological receptors.
Location-specific	Wetlands protection ARARs do not apply to this alternative because no action would be taken.
Action-specific	RCRA hazardous waste units ARARs would be met. Post-closure groundwater monitoring would meet RCRA Releases from SWMU's ARAR.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Minimal action eliminates or reduces potential risk to ecological receptors that cannot pass the constructed fence boundary (e.g., deer). The minimal action alternative does not reduce potential risk to ecological receptors such as birds and shrews.
Adequacy and Reliability of Controls	Fencing would limit surface water access to many ecological receptors.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	None.
Amount Destroyed or Treated	None.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	Minimal action does not employ removal or treatment processes to address surface water contamination at the site.
Degree to Which Treatment is Irreversible	Not Applicable.
Type and Quantity of Residuals Remaining After Treatment	Not Applicable.
Short-term Effectiveness	
Protection of Community During Remedial Action	Because this alternative provides only a minimal response action (i.e., installation of fencing and signs), threats to the community are unlikely to be encountered during implementation.

(continued)

TABLE 11-14
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SW1
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE WATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SW1 MINIMAL ACTION
Protection of Workers During Remedial Action	Threats to site-worker health are very unlikely to be encountered during implementation of this alternative. Workers should follow safe working practices.
Environmental Impacts	No environmental impacts are expected during implementation.
Time Until Remedial Action Objectives Are Achieved	Minimal action does not achieve the remedial response objectives.
Implementability	
Ability to Construct and Operate the Technology	Installing fencing and posting warning signs at the Nitroglycerine, Overflow, and Rocket Paste Ponds are easily implemented construction tasks.
Reliability of the Technology	If fencing is adequately maintained it should be effective in limiting surface water access by human and some ecological receptors.
Ease of Undertaking Additional Remedial Actions, if Necessary	Minimal action would not limit or interfere with the ability to perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Annual visual inspections would be sufficient for monitoring minimal action effectiveness.
Ability to Obtain Approvals and Coordinate with Other Agencies	Coordination with appropriate Army officials, WDNR, and the City of Baraboo would be required if these controls are applied. Coordination with Sauk County would be required to implement and maintain a public education program.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Not Applicable.
Availability of Necessary Equipment and Specialists	Local contractors and necessary materials are readily available to construct fencing and warning signs as well as conduct educational programs.
Availability of Technology	Not Applicable.
Costs	
Capital Cost	$138,000
Present Worth of Operation and Maintenance Cost	$211,000
Net Present Worth Cost	$349,000

TABLE 11–15
COST SUMMARY TABLE
ALTERNATIVE NP/RPA–SW2: SURFACE WATER TREATMENT BY PRECIPITATION/MICROFILTRATION

FEASIBILITY STUDY
NITROGLYCERINE POND/ROCKET PASTE AREA
BADGER ARMY AMMUNITION AREA

ITEM		TOTAL COST
DIRECT COST		
Treatability Study	$	12,000
Site Preparation and Mob/Demob		188,000
Bypass Pumping		57,000
Pumping to Treatment Facility		51,000
Water Treatment by Precipitation		314,000
Confirmation Sampling		25,000
Discharge to Main Ditch		2,000
TOTAL DIRECT COST	$	649,000
INDIRECT COST		
Health and Safety @ 5% of Total Direct Cost	$	32,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		32,000
Engineering @ 10% of Total Direct Cost		65,000
Services During Construction, QA/QC, Documentation @ 10% of Total Direct Cost		65,000
TOTAL INDIRECT COST	$	194,000
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$	843,000
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	0
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	$	0
TOTAL COST FOR SW–2 SURFACE WATER TREATMENT BY PRECIPITATION/ MICROFILTRATION	$	843,000

TABLE 11-16
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SW2
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE WATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SW2 PRECIPITATION/MICROFILTRATION
Overall Protection of Human Health and the Environment	
Human Health Protection	There are no unacceptable excess health risks posed by chemicals in surface water at the NG/RPA ponds.
Environmental Protection	Achieves remedial action objectives for aquatic and semi-aquatic receptors except for the possible nonattainment of the RG for HG.
Compliance with ARARs	
Chemical-specific	No chemical-specific ARARs available for Nitroglycerine Pond surface water. RGs are based on ecological risk.
Location-specific	Wetlands protection ARARs would be met for remediation of the ponds because no practicable alternative less harmful to the wetlands is available to meet the RGs. The USFWS, NMFS, and other related agencies must be consulted before modifying the ponds. A permit may be required from the U.S. Army Corps of Engineers.
Action-specific	RCRA hazardous waste units ARARs would be met. Post-closure groundwater monitoring would meet RCRA Releases from SWMU's ARAR. RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR - Part 264) may apply. If applicable, a program which incorporates the standards would be implemented.
Other Criteria, Advisories, and Guidances	None.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Surface water would be treated to comply with RGs. If HG concentrations in treated water discharged to the Main Ditch exceeds the RG, it is expected to contribute a very small residual risk to environmental receptors.
Adequacy and Reliability of Controls	Treatment would be expected to remove the majority of surface water contaminants. A treatability study would ensure that remediation goals are met. Handling and disposal of the metals-contaminated sludge must be properly managed to ensure protection of human and ecological receptors.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Precipitation followed by microfiltration would be used to remove metals that exceed RGs.
Amount Destroyed or Treated	Approximately 5 million gallons of surface water would be treated.

(continued)

TABLE 11-16
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SW2
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE WATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SW2 PRECIPITATION/MICROFILTRATION
Degree of Expected Reductions of Toxicity, Mobility, and Volume	The mobility of metals is reduced by treating the surface water and containing the metals in sludge which would be properly disposed off-site. Toxicity and volume of the metals would not be reduced.
Degree to Which Treatment is Irreversible	Metals precipitation is potentially reversible if the metals leach in the off-site disposal location.
Type and Quantity of Residuals Remaining After Treatment	Sludge will remain as a result of metals precipitation from surface water. The quantity of sludge will vary depending on the type of process used, as determined during treatability testing. Worst case estimate is 10 tons of sludge.
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation.
Protection of Workers During Remedial Action	Adherence to general health and safety practices would insure minimal risk to workers.
Environmental Impacts	The Rocket Paste Area is not considered critical wildlife habitat. Waterfowl using the Nitroglycerine Pond would be disturbed during implementation of the alternative.
Time Until Remedial Action Objectives Are Achieved	An estimated 3 to 4 months would be required to achieve the remedial action objectives from the start of remediation.
Implementability	
Ability to Construct and Operate the Technology	Operation of a precipitation and microfiltration system is relatively routine.
Reliability of the Technology	Precipitation and microfiltration are proven, widely used processes for removing metals from water. The processes can be adapted to treat a wide variety of waste streams by changing operating parameters.
Ease of Undertaking Additional Remedial Actions, if Necessary	Additional remediation would not be limited by this technology.
Ability to Monitor Effectiveness of Remedy	Effluent would be tested periodically during treatment.
Ability to Obtain Approvals and Coordinate with Other Agencies	The integrity of the remedial design would have to be demonstrated to federal and state regulators. A wetland permit may be required from the U.S. Army Corps of Engineers. RCRA hazardous waste permit potentially required.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Adequate off-site disposal capacity is available for the residual sludge from the treatment process.

(continued)

TABLE 11-16
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SW2
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE WATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SW2 PRECIPITATION/MICROFILTRATION
Availability of Necessary Equipment and Specialists	Precipitation and microfiltration equipment are readily available. Several vendors would be able to provide the necessary services.
Availability of Technology	Precipitation and microfiltration are readily available technologies.
Costs	
Capital Cost	$843,000
Present Worth of Operation and Maintenance Cost	$0
Net Present Worth Cost	$843,000

TABLE 11-17
COST SUMMARY TABLE
ALTERNATIVE NP/RPA-SW3: SURFACE WATER TREATMENT BY ION EXCHANGE

FEASIBILITY STUDY
NITROGLYCERINE POND/ROCKET PASTE AREA
BADGER ARMY AMMUNITION AREA

ITEM		TOTAL COST
DIRECT COST		
Treatability Study	$	12,000
Site Preparation and Mob/Demob		188,000
Bypass Pumping		57,000
Pumping to Treatment Facility		51,000
Water Treatment by Ion Exchange		314,000
Confirmation Sampling		25,000
Discharge to Main Ditch		2,000
TOTAL DIRECT COST	$	649,000
INDIRECT COST		
Health and Safety @ 5% of Total Direct Cost	$	32,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		32,000
Engineering @ 10% of Total Direct Cost		65,000
Services During Construction, QA/QC, Documentation @ 10% of Total Direct Cost		65,000
TOTAL INDIRECT COST	$	194,000
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$	843,000
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	0
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	$	0
TOTAL COST FOR SW-3 SURFACE WATER TREATMENT BY ION EXCHANGE	$	843,000

TABLE 11-18
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SW3
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE WATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SW3 ION EXCHANGE
Overall Protection of Human Health and the Environment	
Human Health Protection	There are no unacceptable excess human health risks posed by chemicals in surface water at the NG/RPA ponds.
Environmental Protection	Would not achieve remedial action objectives for aquatic and semi-aquatic receptors because of unanticipated breakthrough or leakage of metals through the ion exchange system.
Compliance with ARARs	
Chemical-specific	No chemical-specific ARARs available for Nitroglycerine Pond surface water.
Location-specific	Wetlands protection ARARs would be met for remediation of the ponds because no practicable alternative less harmful to the wetlands is available to meet RGs. The USFWS, NMFS, and other related agencies must be consulted before modifying the ponds. A permit may be required from the U.S. Army Corps of Engineers.
Action-specific	RCRA hazardous waste units ARARs would be met. Post-closure groundwater monitoring would meet RCRA Releases from SWMU's ARAR. RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR - Part 264) may apply. If applicable, a program which incorporates the standards would be implemented.
Other Criteria, Advisories, and Guidances	None.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Treated surface water may not attain RGs for metals. Residual risk to environmental receptors, although reduced, could be significant.
Adequacy and Reliability of Controls	Treatment would be expected to remove the majority of surface water contaminants. A treatability study would ensure that remediation goals are met. Handling and disposal of spent filters must be properly managed to ensure protection of human and ecological receptors.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Ion exchange would be used to remove metals that exceed RGs.
Amount Destroyed or Treated	Approximately 5 million gallons of surface water would be treated.

(continued)

TABLE 11-18
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SW3
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE WATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SW3 ION EXCHANGE
Degree of Expected Reductions of Toxicity, Mobility, and Volume	The mobility of metals is reduced by treating the surface water and containing the metals in filter media and metal sheets, which would then be properly disposed off-site. Toxicity and volume of the metals would not be reduced.
Degree to Which Treatment is Irreversible	Capturing metals in filter media is potentially reversible if the metals leach in the off-site disposal location. Metals would not be expected to leach from metal sheets.
Type and Quantity of Residuals Remaining After Treatment	Spent filters and metal sheets will remain as a result of filtration and ion exchange. The volume of plated metal for off-site disposal is expected to be small.
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation.
Protection of Workers During Remedial Action	Adherence to general health and safety practices would ensure minimal risk to workers.
Environmental Impacts	The Rocket Paste Area is not considered critical wildlife habitat. Waterfowl using the Nitroglycerine Pond would be disturbed during implementation of the alternative.
Time Until Remedial Action Objectives Are Achieved	An estimated 3 to 4 months would be required to achieve the remedial action objectives from the start of remediation.
Implementability	
Ability to Construct and Operate the Technology	Operation of an ion exchange system is relatively routine.
Reliability of the Technology	Ion exchange is a proven, widely used method for removing metals from water. Ion exchange resins must be tailored for treating particular waste streams.
Ease of Undertaking Additional Remedial Actions, if Necessary	Additional remedial actions would not be limited by this technology.
Ability to Monitor Effectiveness of Remedy	Effluent would be tested periodically during treatment.
Ability to Obtain Approvals and Coordinate with Other Agencies	The integrity of the remedial design would have to be demonstrated to federal and state regulators. A wetland permit may be required from the U.S. Army Corps of Engineers. RCRA hazardous waste permit potentially required.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Adequate off-site disposal capacity is available for the spent filters and metal sheets from the treatment process.

(continued)

TABLE 11-18
DETAILED ANALYSIS - ALTERNATIVE NG/RPA-SW3
NITROGLYCERINE POND/ROCKET PASTE AREA SURFACE WATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	NG/RPA-SW3 ION EXCHANGE
Availability of Necessary Equipment and Specialists	Ion exchange equipment is readily available. Several vendors would be able to provide the necessary services.
Availability of Technology	Ion exchange is a readily available technology.
Costs	
Capital Cost	$843,000
Present Worth of Operation and Maintenance Cost	$0
Net Present Worth Cost	$843,000

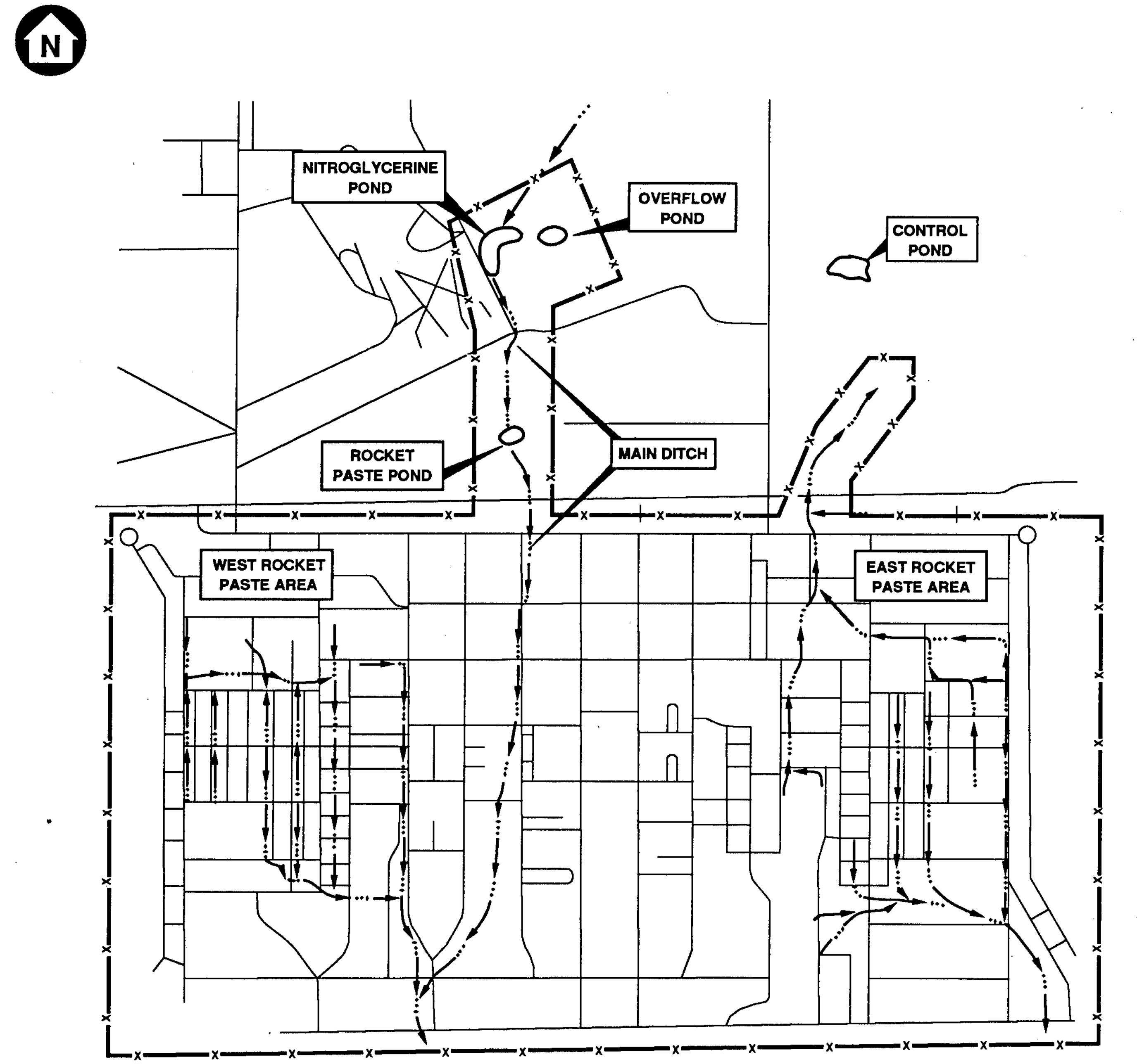
Table 11-19
Comparative Summary of Remedial Alternatives
Nitroglycerine Pond/Rocket Paste Area Surface Water

Feasibility Study
Badger Army Ammunition Plant

Alternative	Overall Protection	Compliance with ARARs	Effectiveness: Long-Term	Reduction of Mobility, Toxicity, and Volume	Effectiveness: Short-Term	Implementability	Cost
NG/RPA-SW1: Minimal Action	Reduces risks to some ecological receptors (e.g., deer) by restricting access to the ponds.	Would not meet chemical-specific ARARs. Location- and action-specific ARARs do not apply.	Not applicable because remedial action objectives are not achieved.	Contamination is not treated or destroyed; no reduction of toxicity, mobility or volume of contaminants.	Minimal impact to community or workers during implementation.	Easily implementable.	Total Present Worth: $349,000 Capital Cost: $138,000 Annual O&M: $13,000
NG/RPA-SW2: Precipitation/ Microfiltration	Meets remedial action objectives by reducing risks to ecological receptors by reducing metals concentrations in the surface water to RGs (except for HG whose RG may not be met with currently available technology).	Chemical-specific ARARs (i.e., RGs) would be met (except for possibly HG). Wetland protection ARARs would be met. Action-specific ARARs would be attained.	Would be capable of maintaining protection as long as future runoff would not carry contamination into the NG Pond.	Toxicity and volume would not be reduced. Metals would be concentrated into a residual sludge. Mobility would be reduced by disposal of residual sludge at a licensed off-site disposal facility.	Minimal impact to the community during implementation. Minimal risk to workers if proper health and safety procedures are followed. Water quality may be adversely affected by chemicals used during precipitation.	No implementability concerns. Processes can be adapted to treat a wide variety of waste streams.	Total Present Worth: $843,000 Capital Cost: $843,000 Annual O&M: $0
NG/RPA-SW3: Ion Exchange	Would reduce risks to human and ecological receptors, but may not reduce metals concentrations to RGs.	Chemical-specific ARARs (i.e., RGs) would not be met. Wetland protection ARARs would be met. Action-specific ARARs would be attained.	Not applicable because remedial action objectives may not be achieved.	Toxicity or volume would not be reduced. Metals would concentrated into filters and metal sheets. Mobility of metals in spent filters would be reduced by disposal of spent filters at a licensed off-site disposal facility. Metal sheets would not require special disposal.	Minimal impact to the community during implementation. Minimal risk to workers if proper health and safety procedures are followed.	Significant implementability concerns. Process is subject to breakthrough and leakage of metals.	Total Present Worth: $843,000 Capital Cost: $843,000 Annual O&M: $0

Notes:

RG = Remediation Goal
ARARs = Applicable or Relevant and Appropriate Requirements



LEGEND

PAVED ROAD OR TRAMWAY

DRAINAGE DITCH

FENCE

NOTE:

1. BASE MAP FROM 300-SCALE SITE TOPOGRAPHIC PLAN PROVIDED BY OLIN CORPORATION.

SCALE IN FEET

0 1200 2400

FIGURE 11-1
SITE FENCING FOR SOIL/SEDIMENT MINIMAL ACTION NITROGLYCERINE POND AND ROCKET PASTE AREA FEASIBILITY STUDY BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9305050D 1

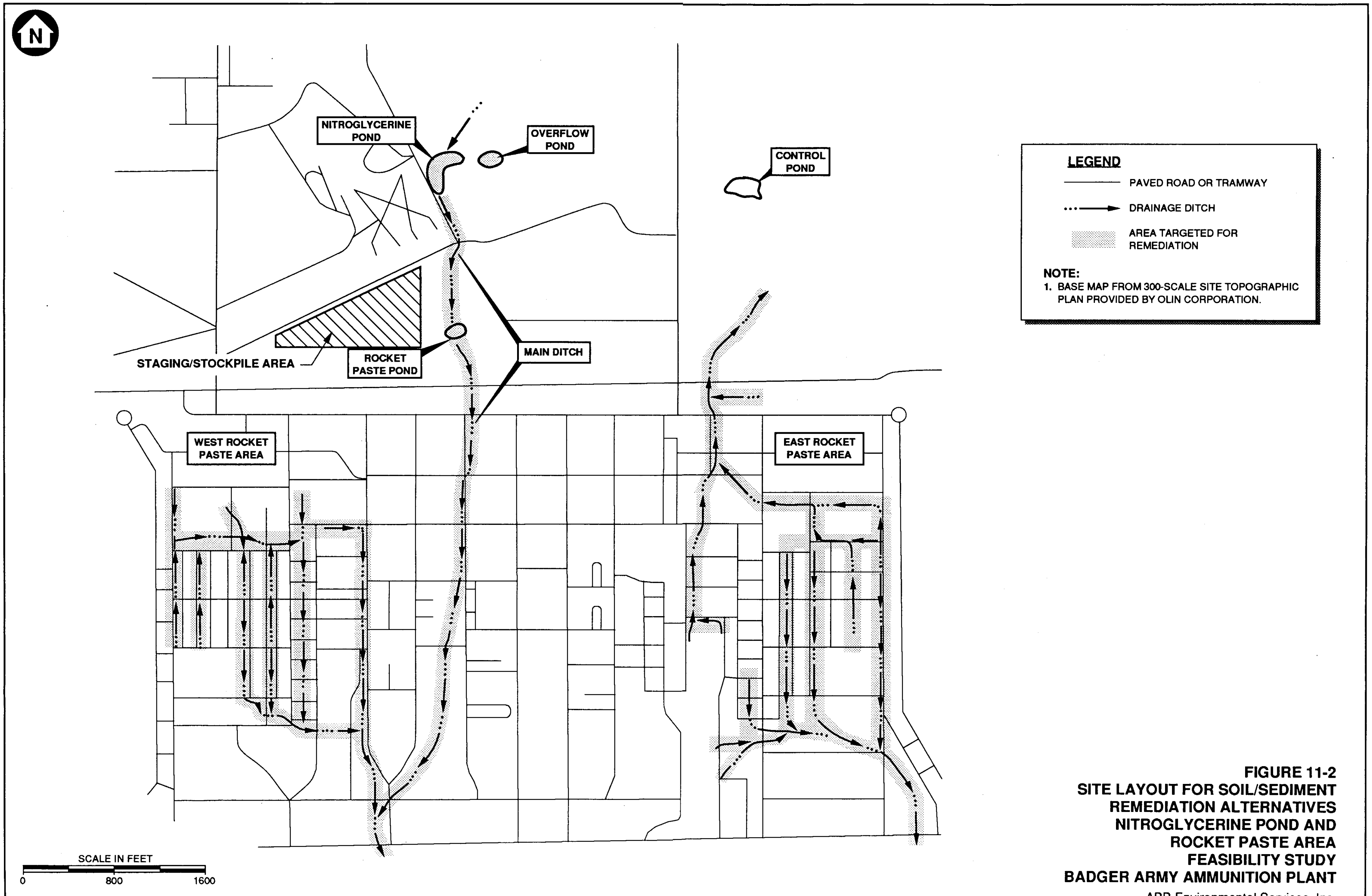


FIGURE 11-2
SITE LAYOUT FOR SOIL/SEDIMENT REMEDIATION ALTERNATIVES NITROGLYCERINE POND AND ROCKET PASTE AREA FEASIBILITY STUDY BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9211071D mn

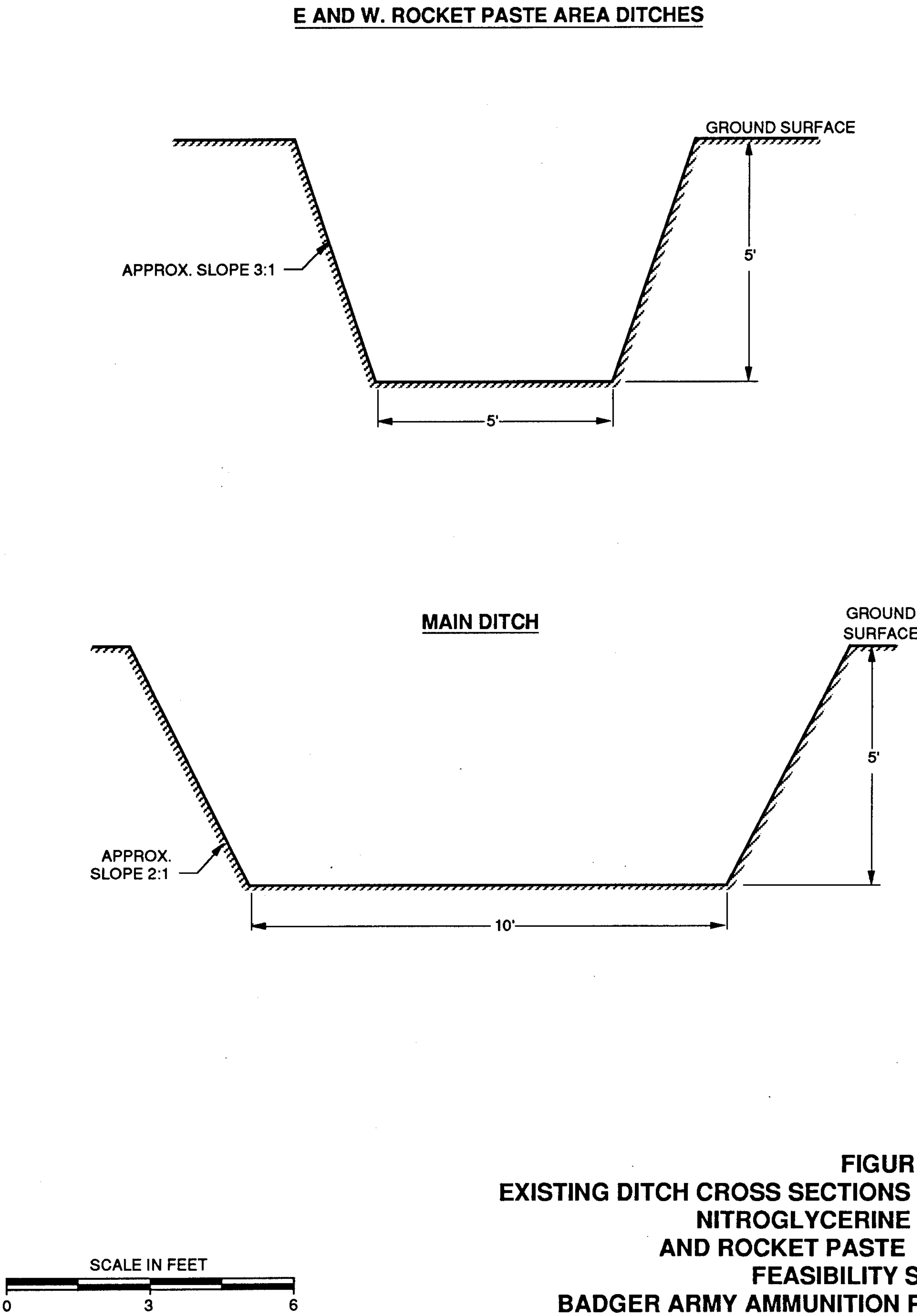
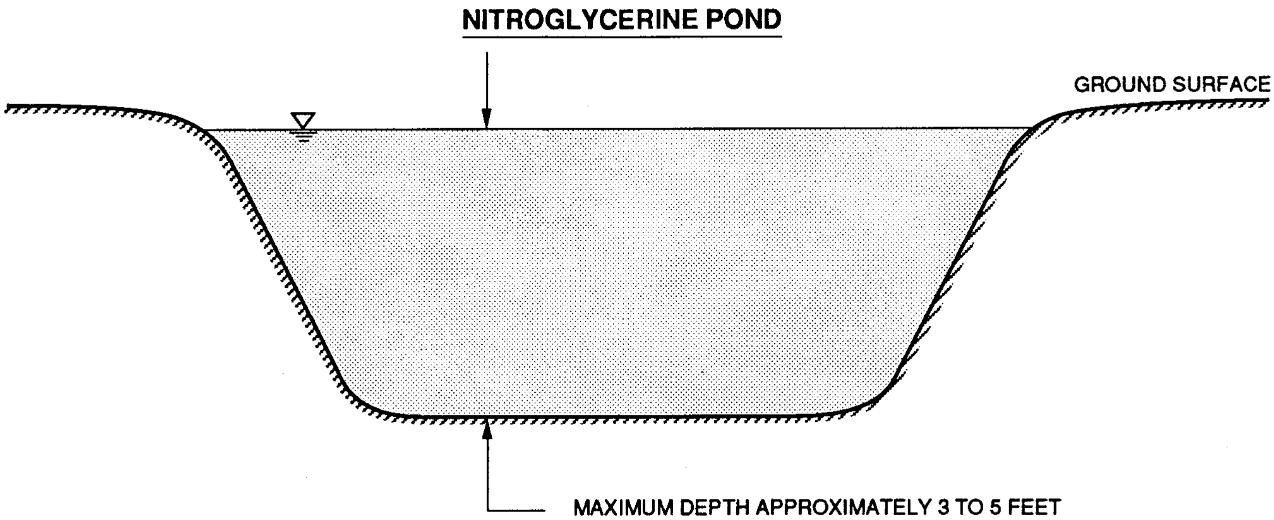
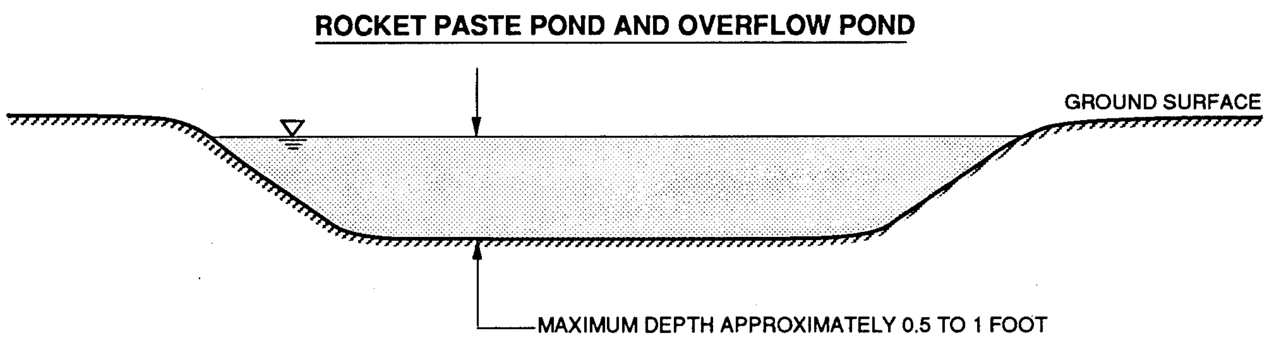


FIGURE 11-3
EXISTING DITCH CROSS SECTIONS (TYP.)
NITROGLYCERINE POND
AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9305046D1





NOT TO SCALE

FIGURE 11-4
PONDS CROSS SECTION (TYP.)
NITROGLYCERINE POND
AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9305048D1

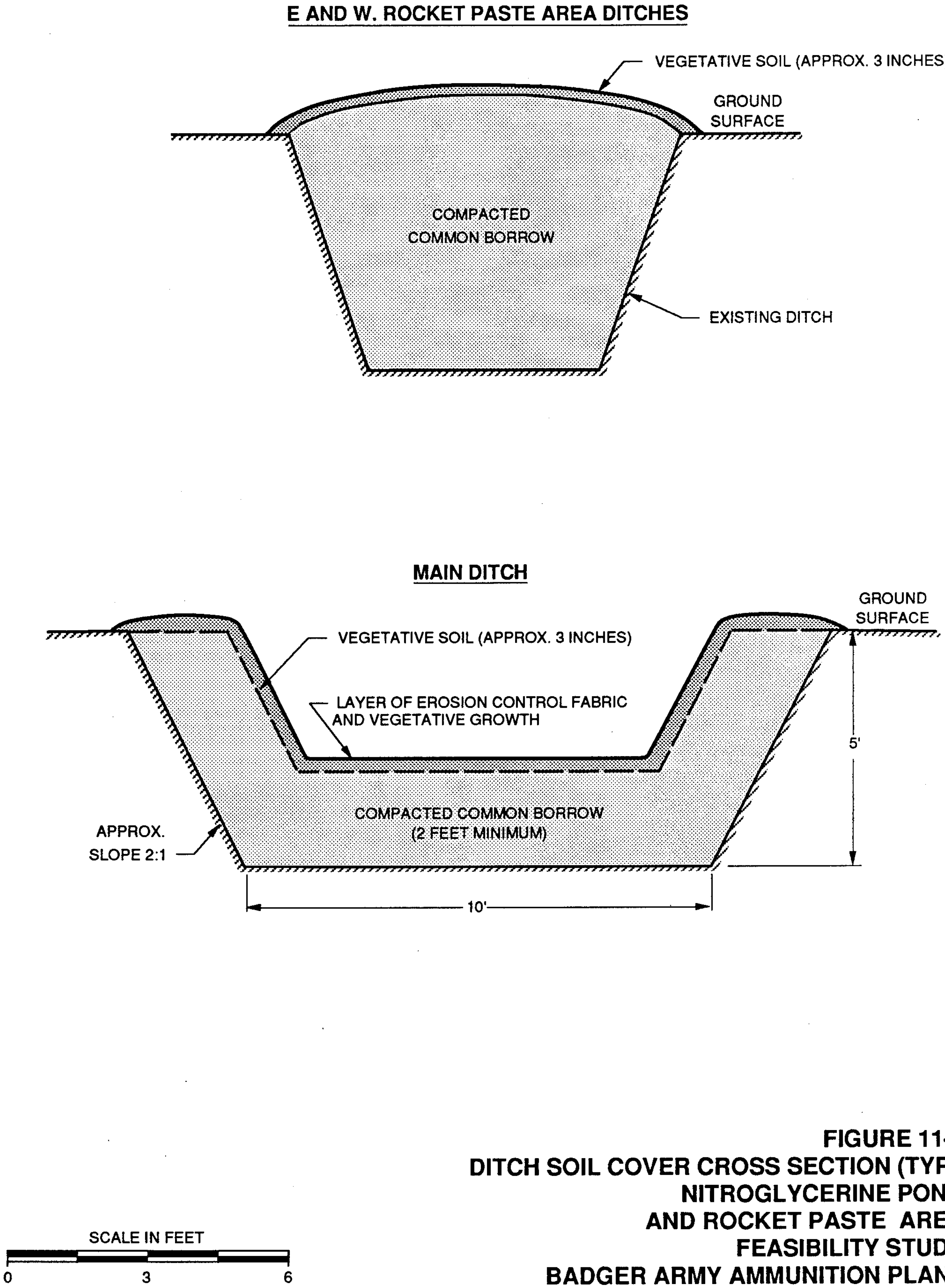
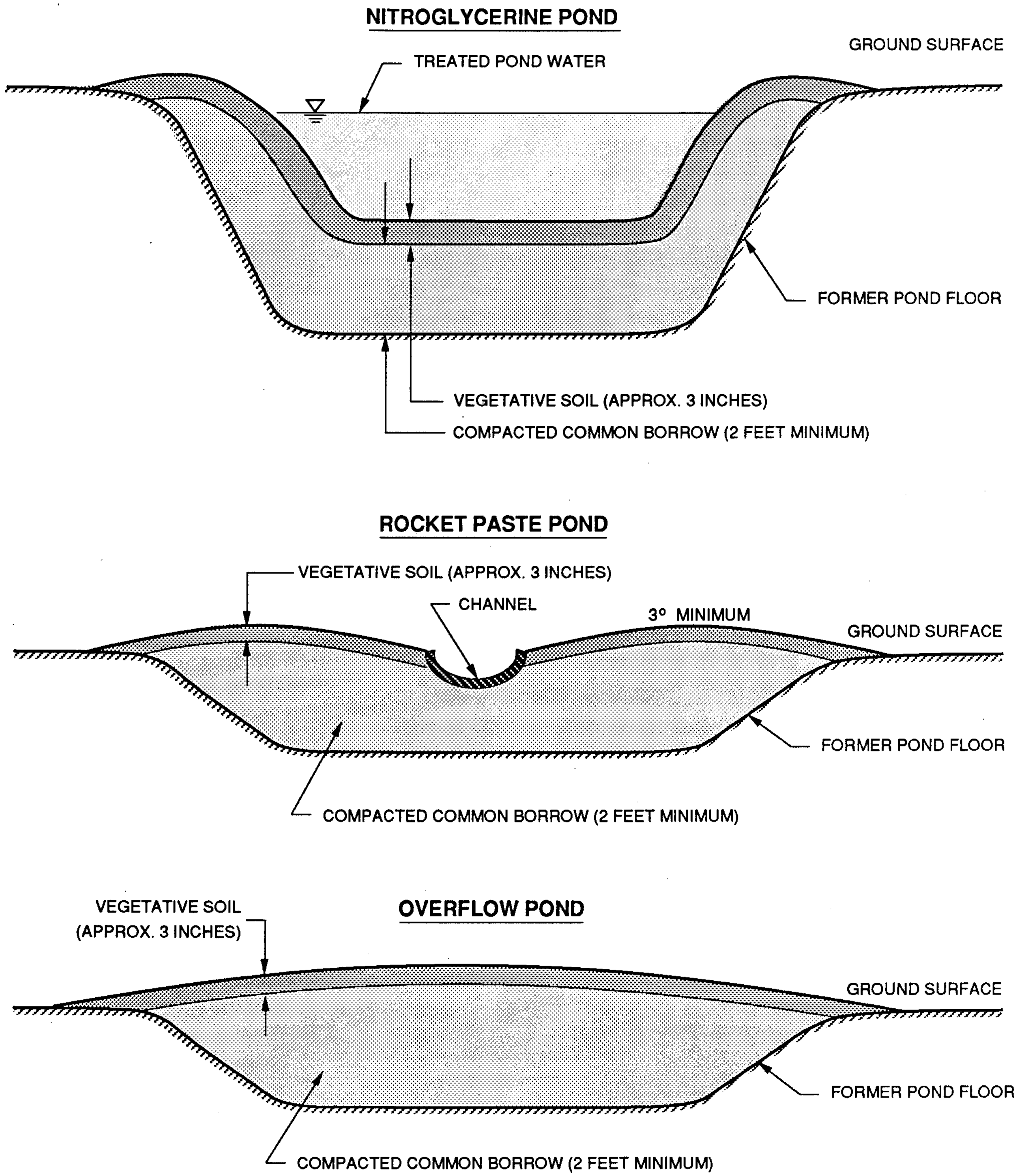


FIGURE 11-5
DITCH SOIL COVER CROSS SECTION (TYP.)
NITROGLYCERINE POND AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407005D (b) 2



NOT TO SCALE

FIGURE 11-6
PONDS SOIL COVER CROSS SECTION (TYP.)
NITROGLYCERINE POND
AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407005D(c) 3

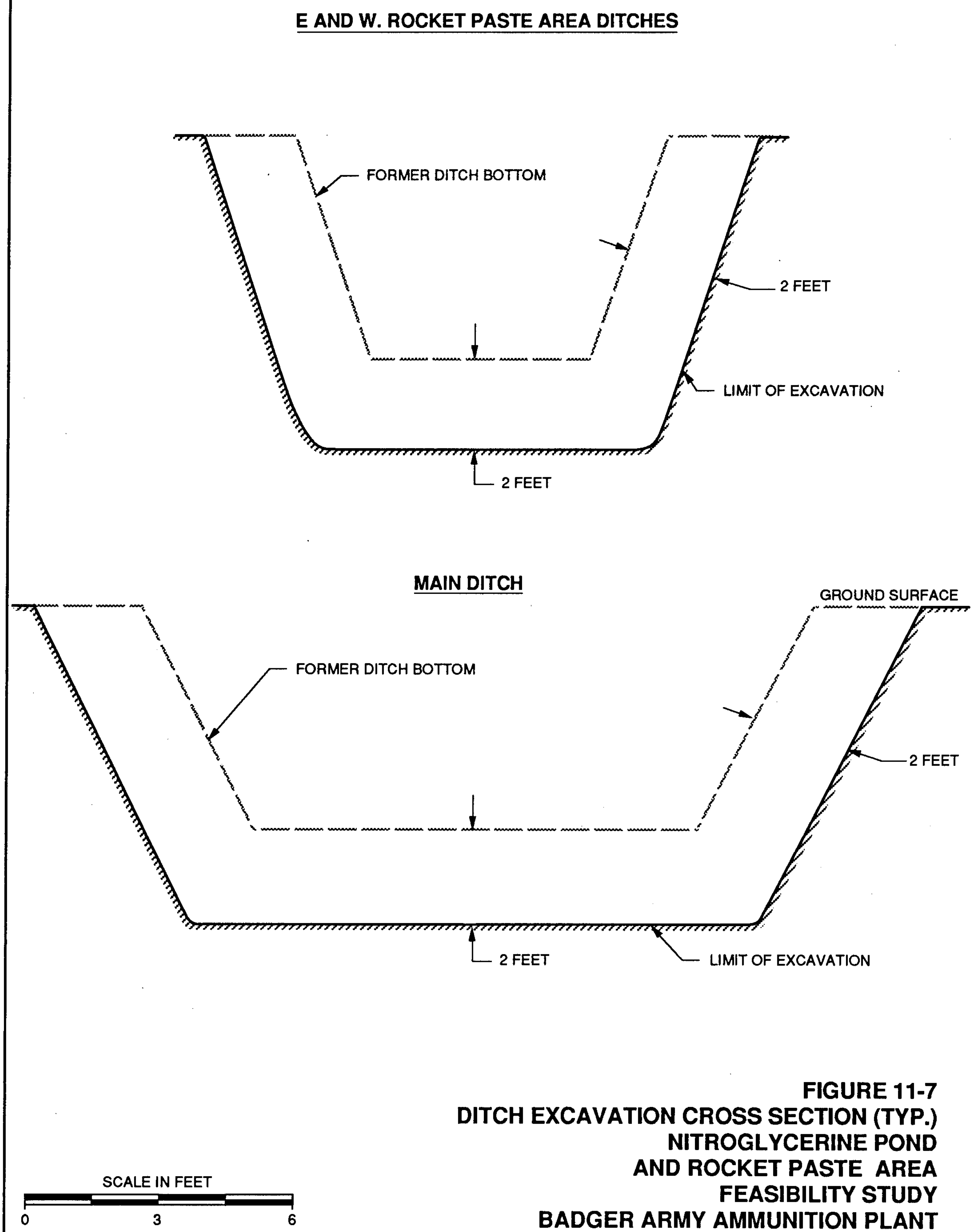
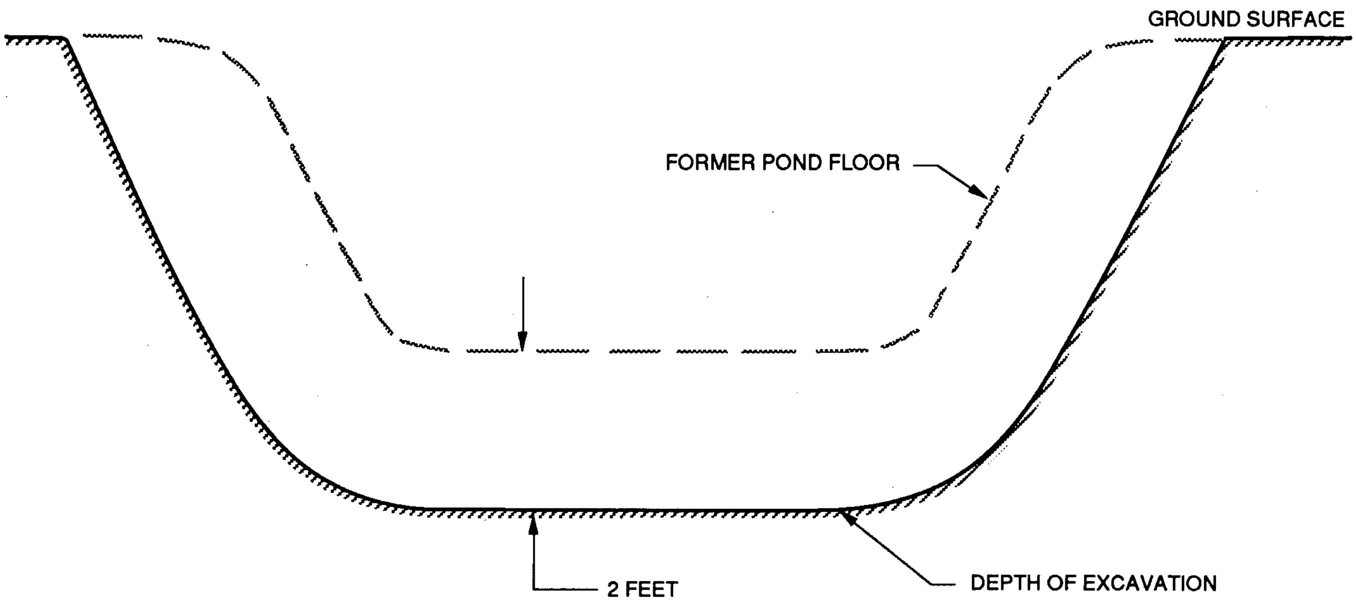


FIGURE 11-7
DITCH EXCAVATION CROSS SECTION (TYP.)
NITROGLYCERINE POND
AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

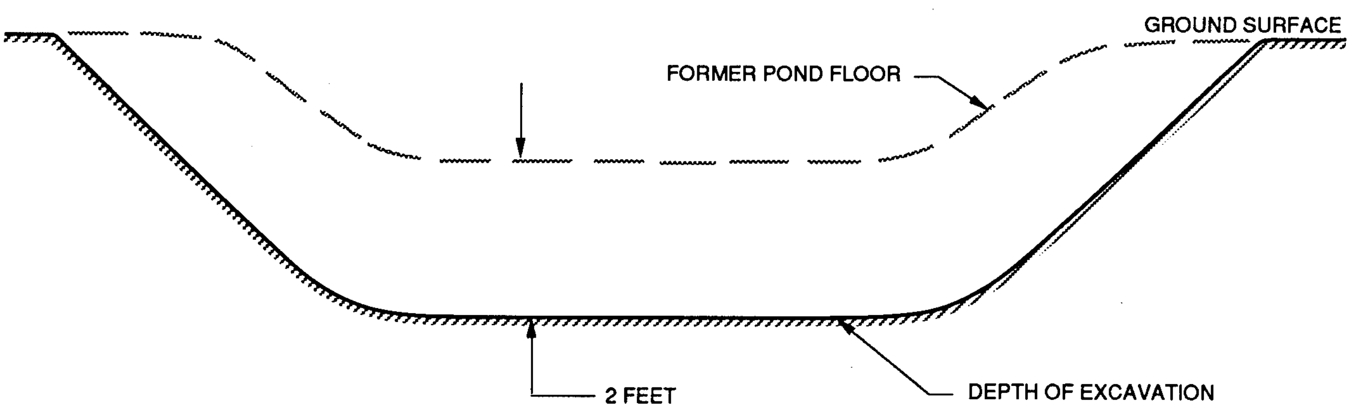
ABB Environmental Services, Inc.

9305046D 4

NITROGLYCERINE POND



ROCKET PASTE POND AND OVERFLOW POND

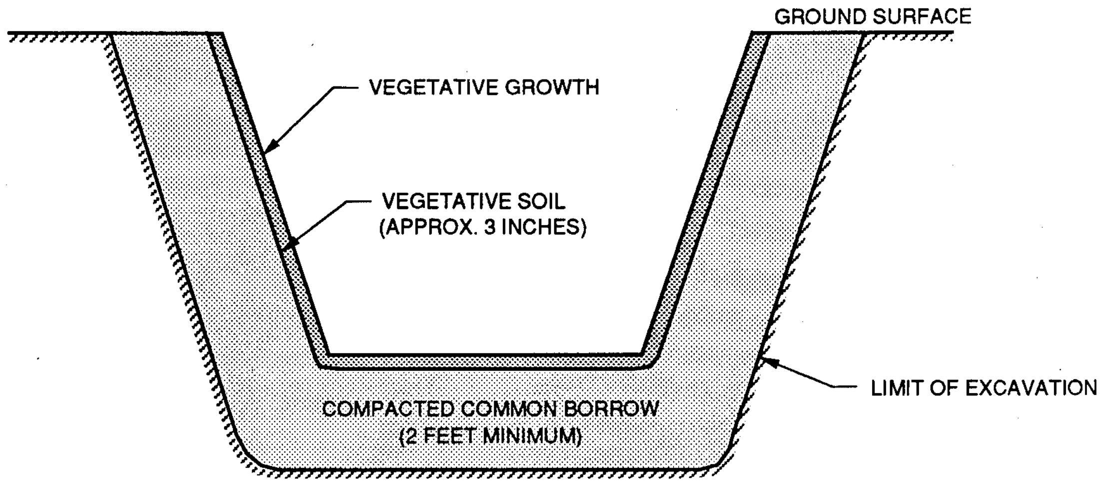


NOT TO SCALE

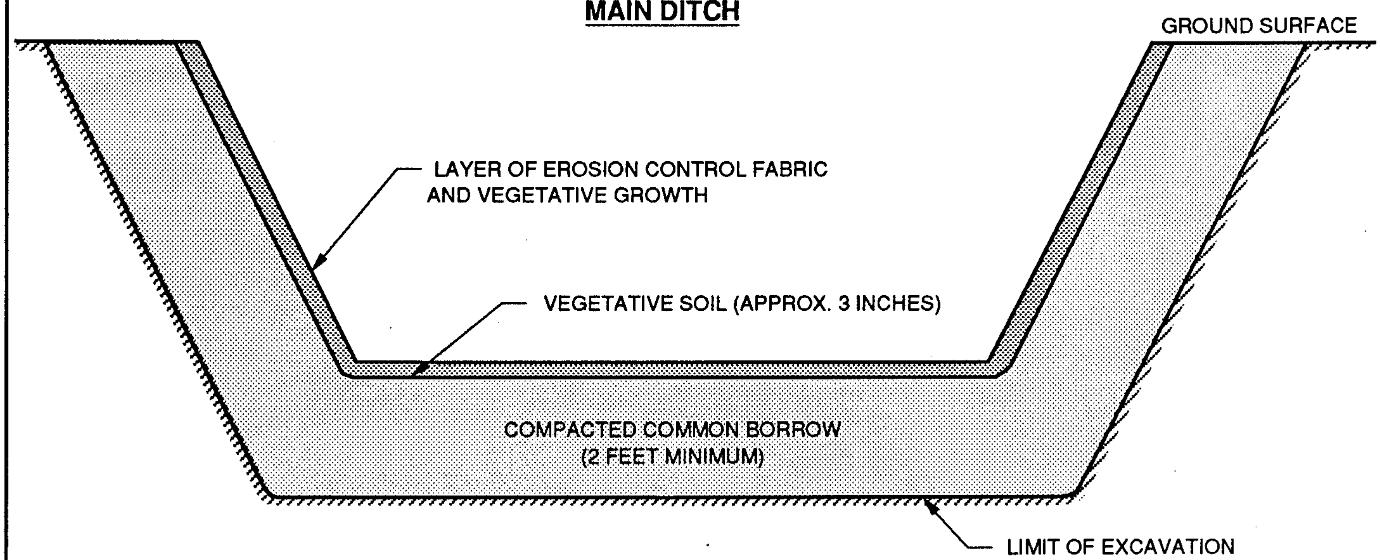
FIGURE 11-8
PONDS EXCAVATION CROSS SECTION (TYP.)
NITROGLYCERINE POND
AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

E AND W. ROCKET PASTE AREA DITCHES



MAIN DITCH



SCALE IN FEET

0 3 6

FIGURE 11-9
DITCH BACKFILL CROSS SECTION (TYP.)
NITROGLYCERINE POND
AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407005D (b) 3

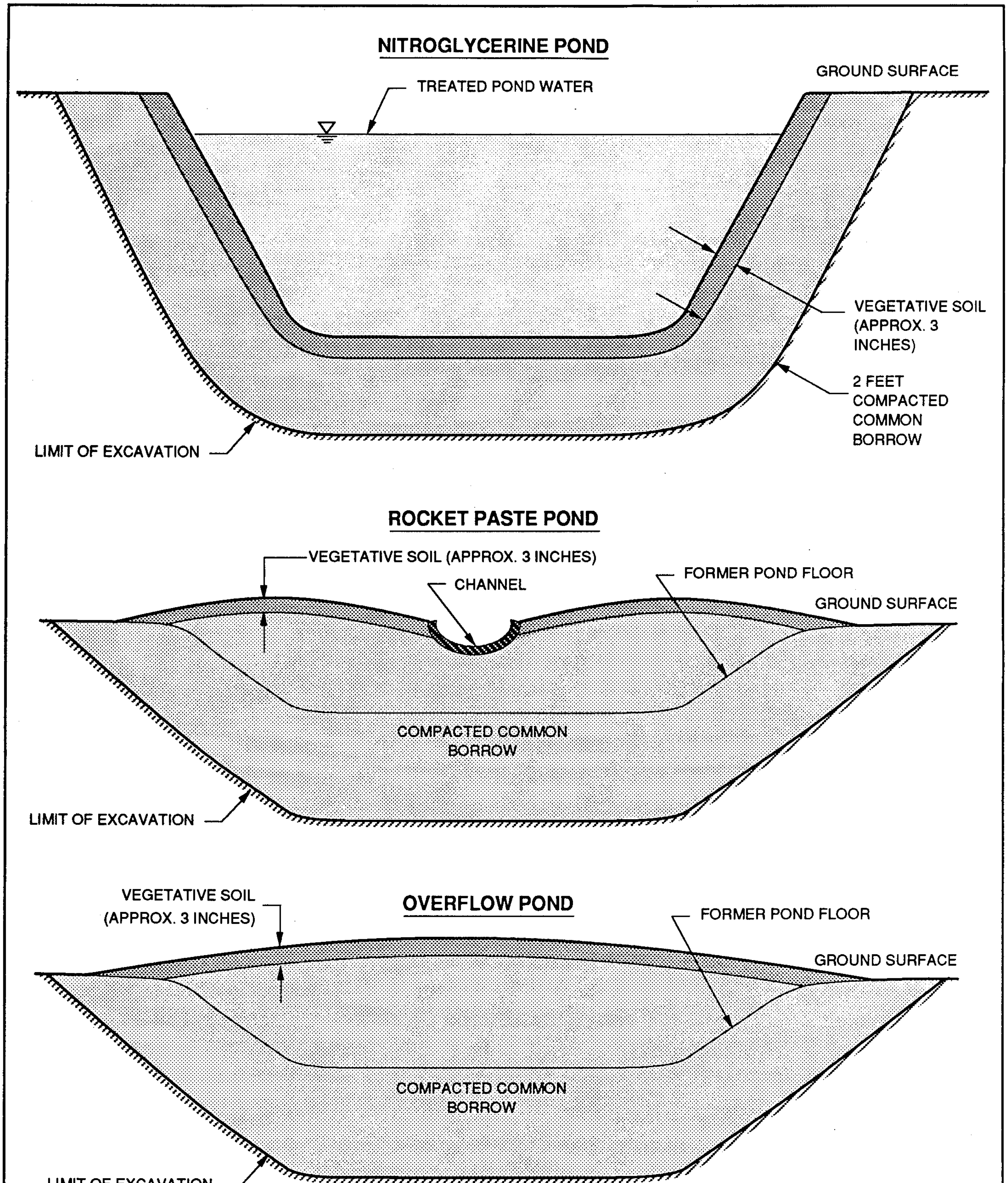
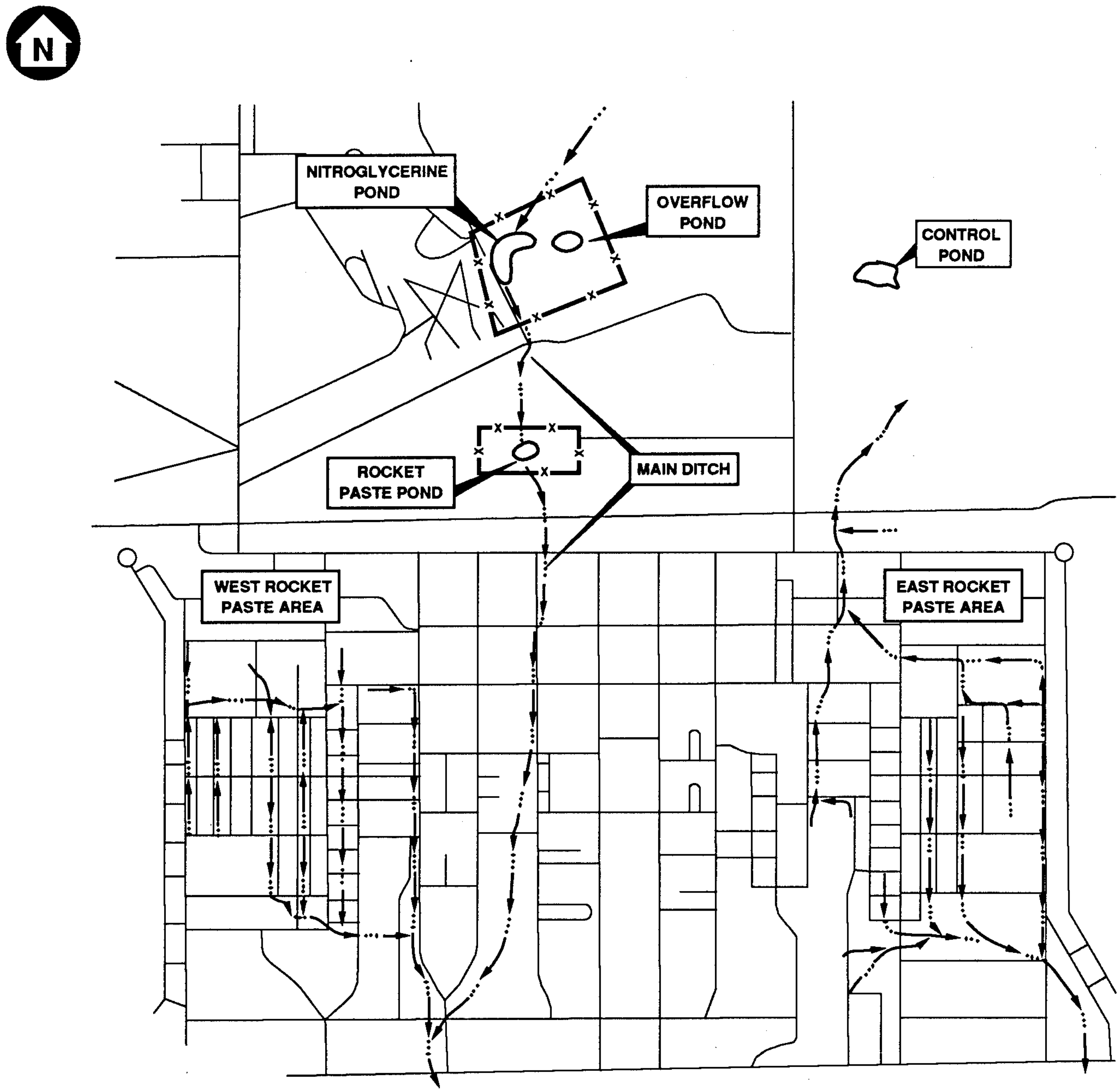


FIGURE 11-10
PONDS BACKFILL CROSS SECTION (TYP.)
NITROGLYCERINE POND
AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

NOT TO SCALE

ABB Environmental Services, Inc.

9407005D(c) 4



LEGEND

PAVED ROAD OR TRAMWAY

DRAINAGE DITCH

FENCE

NOTE:

1. BASE MAP FROM 300-SCALE SITE TOPOGRAPHIC PLAN PROVIDED BY OLIN CORPORATION.

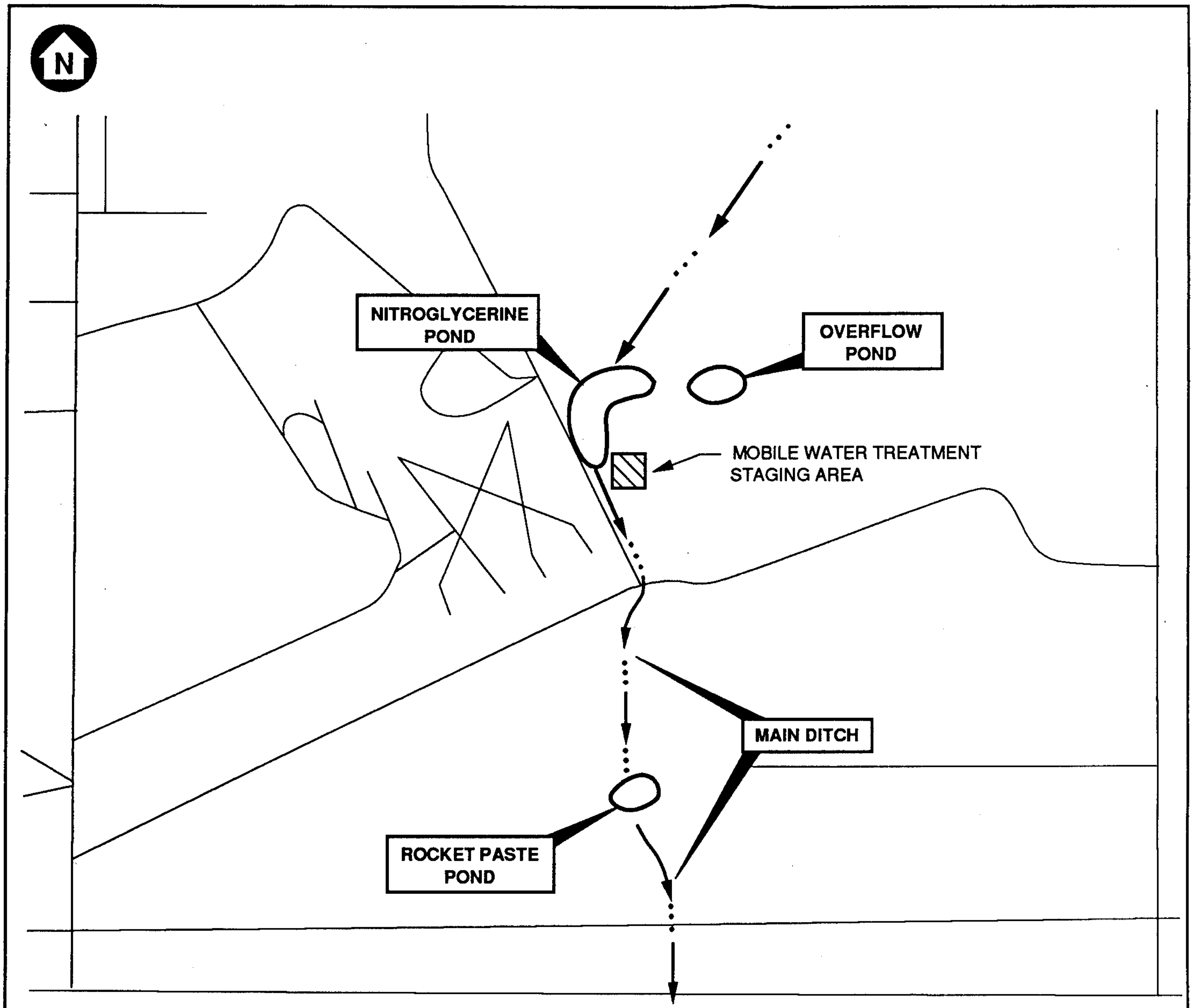
SCALE IN FEET

0 1200 2400

FIGURE 11-11
SITE FENCING FOR SURFACE WATER MINIMAL ACTION NITROGLYCERINE POND AND ROCKET PASTE AREA FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9305050D 2



LEGEND

——— PAVED ROAD OR TRAMWAY

•••——► DRAINAGE DITCH

NOTE:

1. BASE MAP FROM 300-SCALE SITE TOPOGRAPHIC PLAN PROVIDED BY OLIN CORPORATION.

SCALE IN FEET

0 600 1200

FIGURE 11-12
SITE LAYOUT FOR SURFACE WATER TREATMENT
NITROGLYCERINE POND AND
ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407005D(d) 1

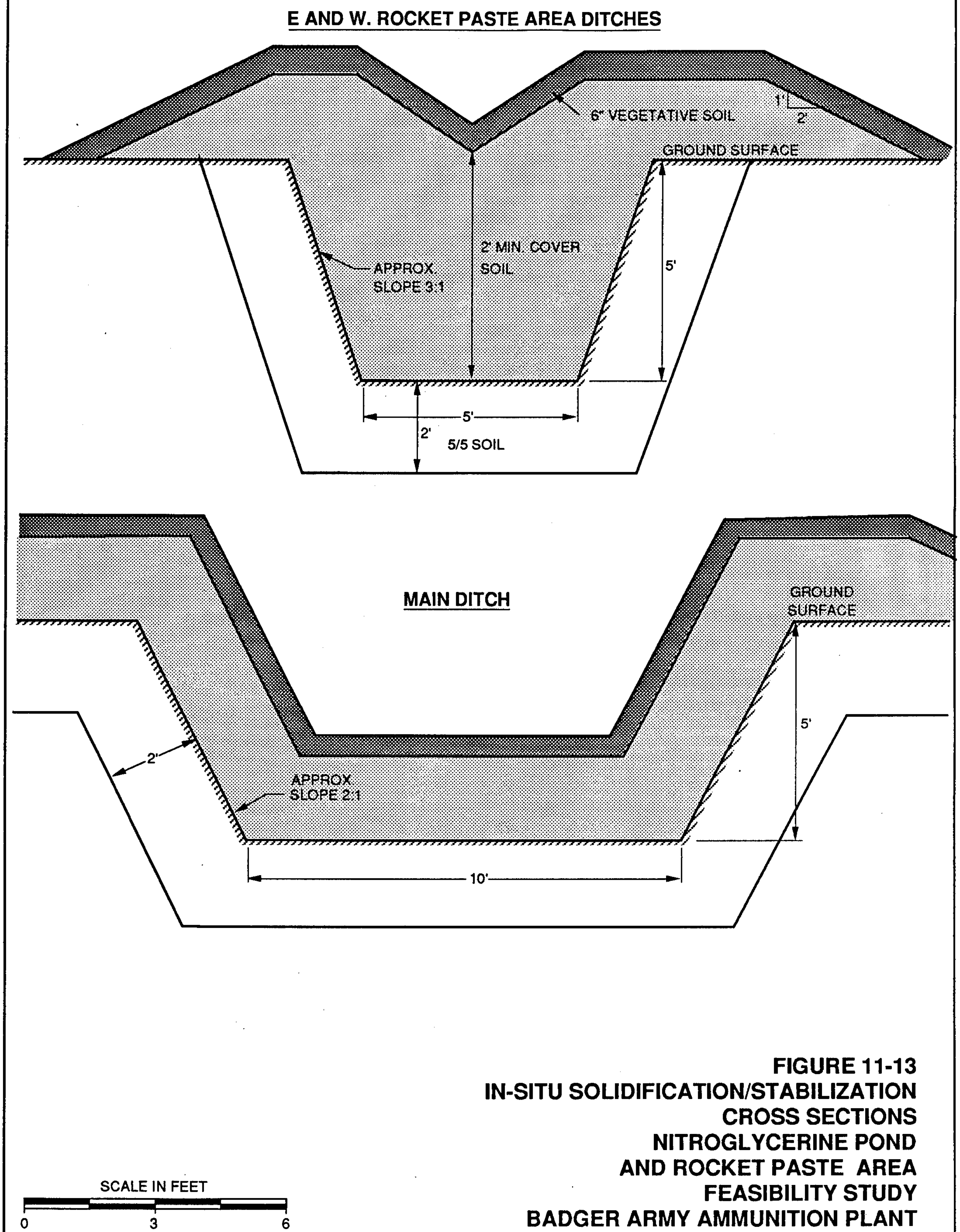


FIGURE 11-13
IN-SITU SOLIDIFICATION/STABILIZATION
CROSS SECTIONS
NITROGLYCERINE POND
AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407005D1(e)

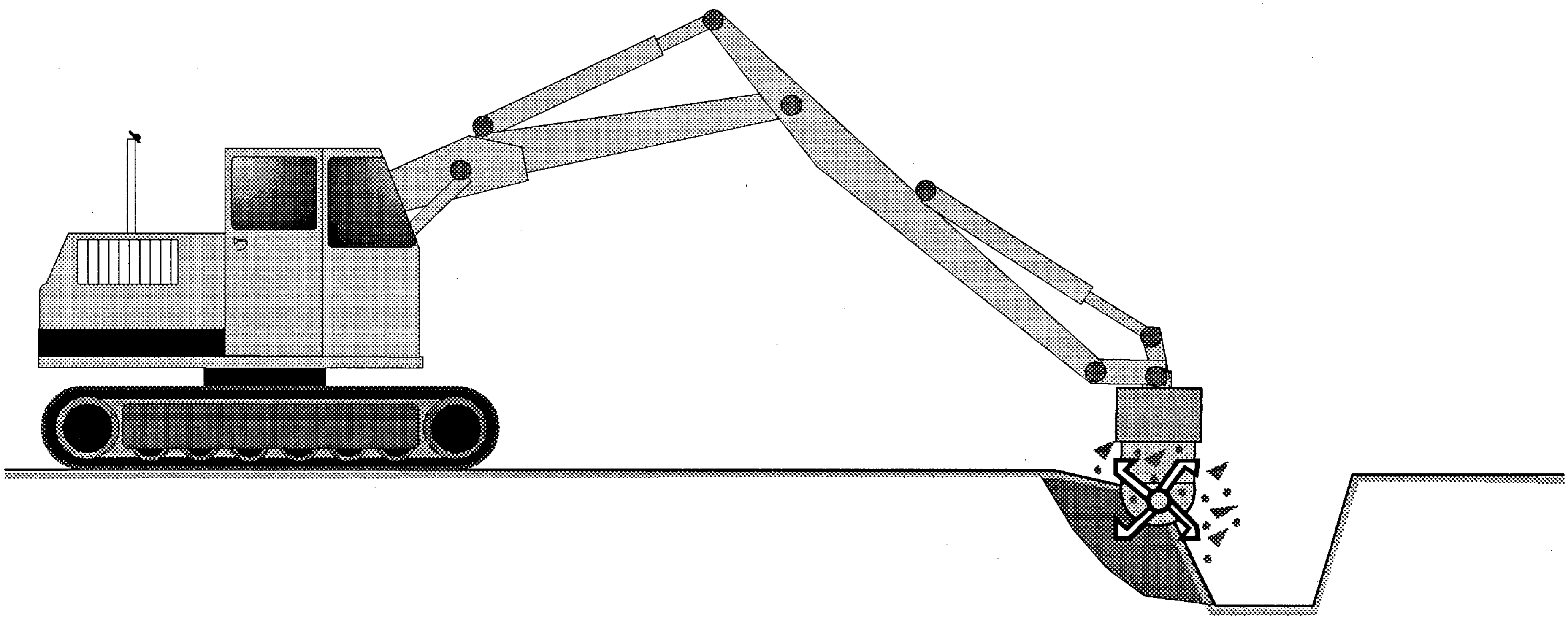


FIGURE 11-14
PLAN IN-SITU SOLIDIFICATION/STABILIZATION OPERATIONS
NITROGLYCERINE POND AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

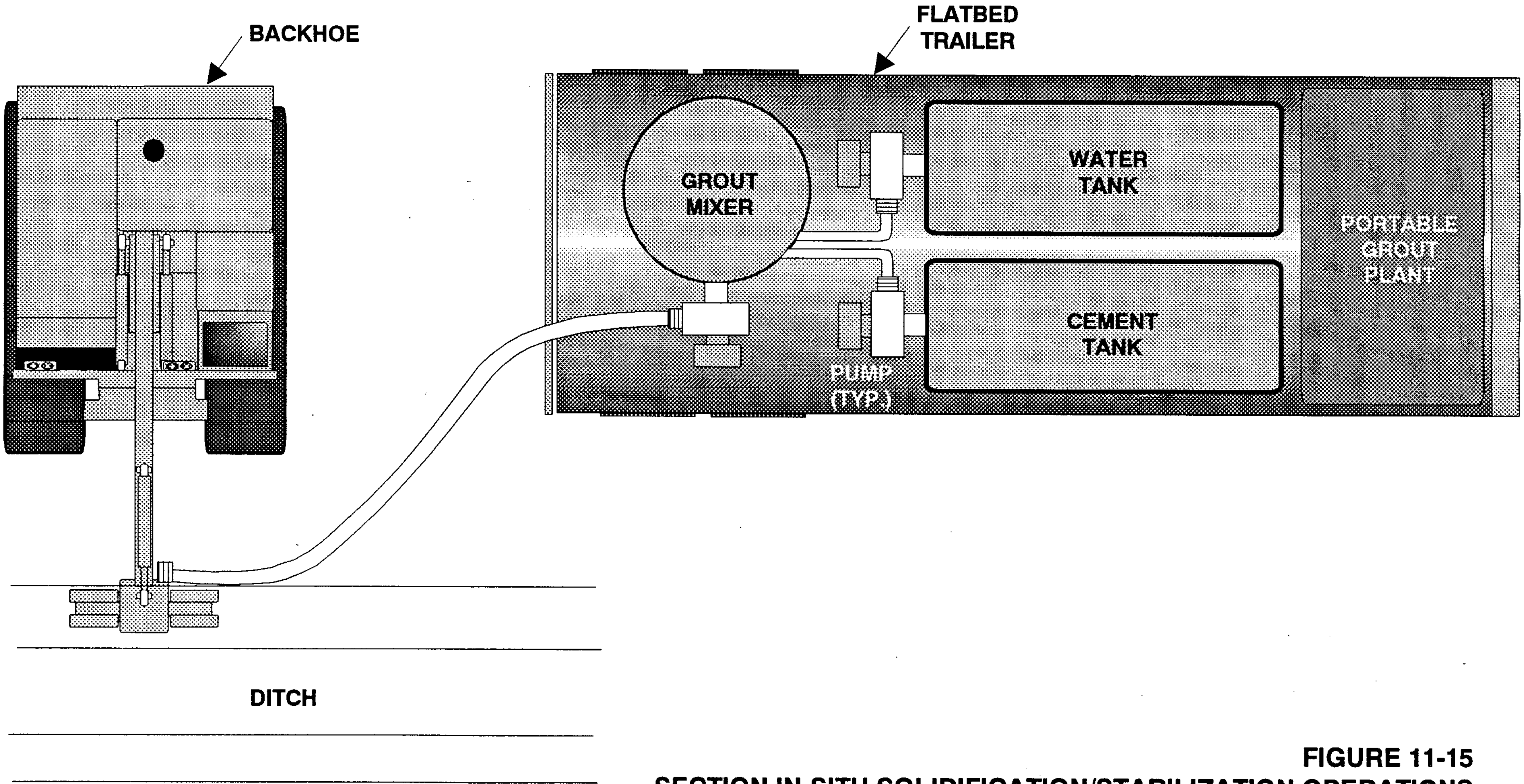


FIGURE 11-15
SECTION IN-SITU SOLIDIFICATION/STABILIZATION OPERATIONS
NITROGLYCERINE POND AND ROCKET PASTE AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

W9407030D

TABLE 12-1
GROUNDWATER MONITORING PROGRAM
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA

FEASIBILITY STUDY REPORT
BADGER ARMY AMMUNITION PLANT

Groundwater Monitoring Locations

S 1101	S 1152 A
S 1102	S 1152 B
S 1103	SPN 8901 C
S 1104	SPN 8902 A, B & C
S 1105	SPN 8903 B & C
S 1106	SPN 8904 B & C
S 1107	SPN 8905 A & B
S 1108	SPN 9102 D
S 1133	SPN 9103 D
S 1147	SPN 9104 D
S 1148	S 1149

Analytical Parameters and Monitoring Frequency

Quarterly	Annually
pH	VOCs, SVOCs, and Metals (Filtered)[1]
Specific Conductance	
Nitrate Nitrogen	
Carbon Tetrachloride	
Trichloroethylene	
Chloroform	
Benzene	
Chromium (filtered)	

Notes:

1 VOCs, SVOCs, and Metals as described by WDNR (WDNR, 1992).

TABLE 12-2
COST SUMMARY TABLE
ALTERNATIVE SP-SS1: MINIMAL ACTION

FEASIBILITY STUDY
SETTLING PONDS
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST MINIMAL ACTION		
Institutional controls	$	10,000
TOTAL DIRECT COST MINIMAL ACTION	**$**	**10,000**
INDIRECT COST MINIMAL ACTION		
Health and Safety @ 5% of Total Direct Cost	$	0
Legal, Administration, Permitting @ 5% of Total Direct Cost		0
Engineering @ 10% of Total Direct Cost		0
Services During Construction @ 10% of Total Direct Cost		0
TOTAL INDIRECT COST MINIMAL ACTION	**$**	**0**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**10,000**
OPERATING AND MAINTENANCE COSTS		
Total Cost Replacement Wells	$	11,000
Total Present Worth of Replacement Wells in Year 16 @ 5%	$	5,000
Total Annual Operating and Maintenance Costs	$	185,000
Total Present Worth of O&M Costs (5% for 30 Years)	$	2,844,000
TOTAL PRESENT WORTH OF O&M COSTS	**$**	**2,849,000**
TOTAL COST FOR SS-1 MINIMAL ACTION	**$**	**2,859,000**

TABLE 12-3
DETAILED ANALYSIS - ALTERNATIVE SSP-SS1
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SSP-SS1 MINIMAL ACTION
Overall Protection of Human Health and the Environment	
Human Health Protection	Minimal Action would reduce potential exposure risks to human receptors by restricting site access.
Environmental Protection	Minimal action does not eliminate or reduce potential risk posed by the soils at Final Creek, Settling Ponds and Spoils Disposal Area.
Compliance with ARARs	
Chemical-specific	There are no promulgated chemical-specific ARARs for soil. However, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Because soil contaminants would not be treated, removed, or destroyed, this alternative would not comply with pathway-specific numeric standards derived from the proposed Chapter NR 720.
Location-specific	RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR - Part 264) may apply. If applicable, a program which incorporates the standards would be implemented. RCRA, Releases from Solid Waste Management Units (Subpart F, 264.90-264.109) may apply for post-closure monitoring of the site. This alternative would include continued groundwater monitoring. Wetlands Protection ARARs do not apply to this alternative because no action would be taken.
Action-specific	RCRA hazardous waste units ARARs would be met. Post closure groundwater monitoring would meet RCRA releases from SWMUs ARAR. Federal OSHA requirements to protect worker health and safety would be followed during the site work. Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.

continued

TABLE 12-3
DETAILED ANALYSIS - ALTERNATIVE SSP-SS1
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SSP-SS1 MINIMAL ACTION
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Under the minimal action alternative, contaminant levels in the soil are not expected to decrease significantly over time. Groundwater quality would continue to be threatened.
Adequacy and Reliability of Controls	There are no physical controls proposed in this alternative. The proposed institutional controls would adequately perform their intended purpose of restriction.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Not Applicable. No treatment is used in this alternative.
Amount Destroyed or Treated	No contamination is treated or destroyed.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	Minimal action does not employ removal or treatment processes to address soil contamination; no reduction of toxicity, mobility, or volume.
Degree to Which Treatment is Irreversible	Not Applicable. No treatment used.
Type and Quantity of Residuals Remaining After Treatment	Not Applicable. No treatment used.
Short-term Effectiveness	
Protection of Community During Remedial Action	Because this alternative provides no response action, threats to the community are unlikely to be encountered during implementation.
Protection of Workers During Remedial Action	No construction is required with this alternative. However, site workers involved in the groundwater monitoring program should follow safe working practices.
Environmental Impacts	There would be no environmental impacts during implementation.
Time Until Remedial Action Objectives Are Achieved	Remedial action objectives would not be achieved with minimal action.
Implementability	
Ability to Construct and Operate the Technology	Not Applicable. No construction is involved with this alternative.
Reliability of the Technology	Not Applicable. No technology is used with this alternative.

continued

TABLE 12-3
DETAILED ANALYSIS - ALTERNATIVE SSP-SS1
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SSP-SS1 MINIMAL ACTION
Ease of Undertaking Additional Remedial Actions, if Necessary	Minimal action would not limit or interfere with the ability to perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	The proposed groundwater monitoring program would adequately monitor contaminant migration.
Ability to Obtain Approvals and Coordinate with Other Agencies	Coordination with appropriate Army officials, WDNR, and the City of Baraboo would be required if these controls are applied. Coordination with Sauk County would be required to implement and maintain a public education program.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Not Applicable. No technology, treatment, or construction is involved.
Availability of Necessary Equipment and Specialists	Local contractors are readily available to conduct educational programs and perform groundwater monitoring.
Availability of Technology	Not Applicable. No technology used.
Costs	
Capital Cost	$10,000
Present Worth of Operation and Maintenance Cost	$2,849,000
Net Present Worth Cost	$2,859,000

TABLE 12-4
COST SUMMARY TABLE
ALTERNATIVE SP-SS3: CAPPING

FEASIBILITY STUDY
SETTLING PONDS
BADGER ARMY AMMUNITION PLANT

ITEM	TOTAL COST
DIRECT COST CAPPING	
Site preparation and mob/demob	$ 903,000
Contaminated soil delineation	111,000
Cap	22,543,000
Surface water management	123,000
TOTAL DIRECT COST CAPPING	**$ 23,680,000**
INDIRECT COST CAPPING	
Health and Safety @ 5% of Total Direct Cost	$ 1,184,000
Legal, Administration, Permitting @ 5% of Total Direct Cost	1,184,000
Engineering @ 10% of Total Direct Cost	2,368,000
Services During Construction @ 10% of Total Direct Cost	2,368,000
TOTAL INDIRECT COST CAPPING	**$ 7,104,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$ 30,784,000**
OPERATING AND MAINTENANCE COSTS	
Total Annual Operating and Maintenance Costs	$ 196,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$ 3,013,000**
TOTAL COST FOR SS-3 CAPPING	**$ 33,797,000**

TABLE 12-5
DETAILED ANALYSIS - ALTERNATIVE SSP-SS3
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SSP-SS3 CAPPING
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objectives for human receptors. The cap and institutional controls would significantly reduce the potential of physical contact with contaminated soil and significantly reduce precipitation infiltration through waste area soil to groundwater.
Environmental Protection	Would meet environmental-based response objectives. Cap would significantly reduce leachate generation such that groundwater is protected. Degree of adverse impact by placing cover soil over local mammal habitat is uncertain.
Compliance with ARARs	
Chemical-specific	Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Because soil contaminants would not be removed or destroyed, this alternative would not comply with pathway-specific numeric standards derived from the proposed Chapter NR 720. However, the caps used in this alternative could be designed to achieve a performance standard which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of human health and groundwater.
Location-specific	RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR - Part 264) may apply. If applicable, a program which incorporates the standards would be implemented. RCRA, Releases from Solid Waste Management Units (Subpart F, 264.90-264.109) may apply for post-closure monitoring of the site. This alternative would include continued groundwater monitoring. Location-specific ARARs pertaining to wetlands, surface water, and landfills may apply to components of this alternative. Permits would be obtained during design and prior to construction.

continued

TABLE 12-5
DETAILED ANALYSIS - ALTERNATIVE SSP-SS3
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SSP-SS3 CAPPING
Action-specific	General RCRA requirements pertaining to permitted Hazardous Waste TSD Units would be addressed by the capping alternative. Dust suppression techniques and other preventive measures would ensure compliance with both state and federal particulate emission standards. Also, fugitive particulate emissions during site work should not exceed exempt-source thresholds under Wisconsin Air Pollution Control Rules. Federal OSHA requirements to protect worker health and safety would be followed during the site work. Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Contaminated material would remain untreated at the site after capping operations are complete; however, potential risks to humans via migration of contaminants to groundwater and to humans and ecological receptors via direct contact is greatly reduced.
Adequacy and Reliability of Controls	Long-term management to maintain cap would be necessary. Capping, if properly maintained, is a reliable control. Institutional controls would protect the caps from invasive activities and restrict residential or public use of the site. Visual inspections would be conducted annually to ensure the integrity of the caps. Long-term groundwater monitoring would detect soil contaminants leaching into groundwater.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Alternative SSP-SS3 does not involve treatment of contaminated soils.
Amount Destroyed or Treated	Contaminants would not be destroyed or treated.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	Toxicity and volume of soil contaminants would not be affected by capping. Contaminant mobility through soil via precipitation infiltration would be greatly reduced.
Degree to Which Treatment is Irreversible	Not Applicable. No treatment is used with this alternative.
Type and Quantity of Residuals Remaining After Treatment	Not Applicable. No treatment is used with this alternative.

continued

TABLE 12-5
DETAILED ANALYSIS - ALTERNATIVE SSP-SS3
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SSP-SS3 CAPPING
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation. There are no residences close enough to the site to be affected by noise or dust.
Protection of Workers During Remedial Action	With the use of dust suppression techniques and adherence to general health and safety practices, there would be minimal risk to workers as no excavation of contaminated soil would occur.
Environmental Impacts	The cap may destroy a portion of the burrowing animal habitat. Appropriate erosion control measures would be employed during implementation to limit environmental impacts.
Time Until Remedial Action Objectives Are Achieved	Implementation should be complete within approximately 6 months.
Implementability	
Ability to Construct and Operate the Technology	Cap construction can be accomplished using standard construction procedures and conventional earth-moving equipment. Cap repairs would be easily implemented.
Reliability of the Technology	Capping is a proven technology for significantly reducing infiltration of precipitation and migration of soil contaminants via leaching. Visual inspections and cap repair, if necessary, would ensure that the integrity of the cap is maintained.
Ease of Undertaking Additional Remedial Actions, if Necessary	The cap would increase the scope of potential future soil excavation and/or treatment. The cap would need to be dismantled if soil removal or in situ soil treatment methods were implemented.
Ability to Monitor Effectiveness of Remedy	Annual visual cap inspections and groundwater monitoring would determine cap effectiveness for significantly reducing groundwater contamination.
Ability to Obtain Approvals and Coordinate with Other Agencies	The integrity of the remedial design would have to be demonstrated to federal and state regulators. A wetlands permit from the U.S. Corps of Engineers may be required. Permits and approvals would be obtained during design and before construction.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Contaminated soil or treatment residuals would not be transported off-site.
Availability of Necessary Equipment and Specialists	Cap materials and contractors with health and safety training are readily available for the construction of the cover system.
Availability of Technology	Not Applicable. No technology used.

continued

TABLE 12-5
DETAILED ANALYSIS - ALTERNATIVE SSP-SS3
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SSP-SS3 CAPPING
Costs	
Capital Cost	$ 30,784,000
Present Worth of Operation and Maintenance Cost	$ 3,013,000
Net Present Worth Cost	$ 33,797,000

TABLE 12–6
COST SUMMARY TABLE
ALTERNATIVE SP–SS7: MODIFIED IN–SITU SOLIDIFICATION AND SOIL COVER

FEASIBILITY STUDY
SETTLING PONDS
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST MODIFIED IN–SITU SOLIDIFICATION AND SOIL COVER		
Treatability testing	$	78,000
Site preparation and mob/demob		3,099,000
Contaminated soil delineation		221,000
In–situ stabilization/solidification		14,081,000
Stabilization/solidification		24,351,000
Cover soil		7,646,000
Surface water management		123,000
TOTAL DIRECT COST MODIFIED IN–SITU SOLIDIFICATION AND SOIL COVER	**$**	**49,599,000**
INDIRECT COST MODIFIED IN–SITU SOLIDIFICATION AND SOIL COVER		
Health and Safety @ 5% of Total Direct Cost	$	2,480,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		2,480,000
Engineering @ 10% of Total Direct Cost		4,960,000
Services During Construction @ 10% of Total Direct Cost		4,960,000
TOTAL INDIRECT COST MODIFIED IN–SITU SOLIDIFICATION AND SOIL COVER	**$**	**14,880,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$	64,479,000
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	196,000
TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS)	**$**	**3,013,000**
TOTAL COST FOR SS–7 MODIFIED IN–SITU SOLIDIFICATION AND SOIL COVER	**$**	**67,492,000**

TABLE 12-7
DETAILED ANALYSIS - ALTERNATIVE SSP-SS7
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SSP-SS7 MODIFIED IN SITU S/S AND SOIL COVER
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objective for protection of human health. Modified in situ S/S, the soil cover, and institutional controls would reduce the potential for human exposure to contaminant concentrations greater than remediation goals. Stabilized/solidified mass would resist erosion and overland migration of contaminants.
Environmental Protection	Achieves the remedial action objectives for terrestrial organisms and protection of groundwater. Modified in situ S/S and the soil cover would reduce the potential for organism exposure to surface soil with contaminant concentrations greater than remediation goals. Modified in situ S/S would significantly reduce leachate generation such that groundwater is protected.
Compliance with ARARs	
Chemical-specific	Chemical-specific ARARs have not been promulgated for contaminated soil; however, TBC soil clean-up standards for protection of human health and groundwater have been derived from the proposed Wisconsin Chapter NR 720, Wisconsin Administrative Code, and are being applied to BAAP soil remediation. Because soil contaminants would not be removed or destroyed, this alternative would not comply with pathway-specific numeric standards derived from the proposed Chapter NR 720. However, the modified in situ S/S and soil cover used in this alternative could be designed to achieve a performance standard which would meet the intent of the proposed Chapter NR 720 clean-up standards for protection of human health and groundwater.
Location-specific	RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR - Part 264) may apply. If applicable, a program which incorporates the standards would be implemented. RCRA, Releases from Solid Waste Management Units (Subpart F, 264.90-264.109) may apply for post-closure monitoring of the site. This alternative would include continued groundwater monitoring at the Settling Ponds/Spoils Disposal Area. Wisconsin Hazardous Waste Management and Facility Regulations are essentially equivalent to federal RCRA regulations and as such, the degree of ARARs compliance with standards established by Wisconsin hazardous waste regulations can be inferred from the degree of ARARs compliance with RCRA.

TABLE 12-7
DETAILED ANALYSIS - ALTERNATIVE SSP-SS7
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

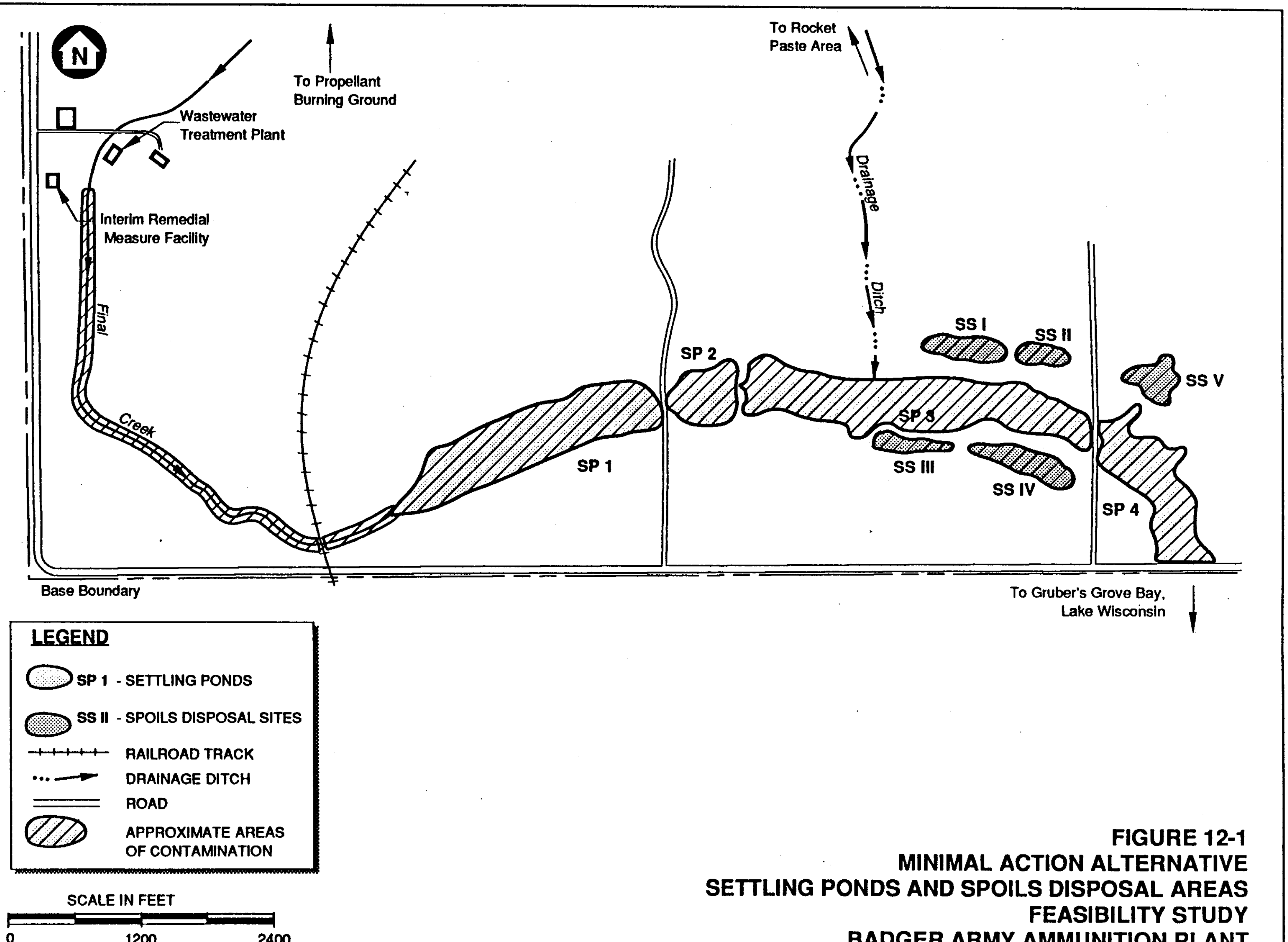
EVALUATION CRITERIA	ALTERNATIVE SSP-SS7 MODIFIED IN SITU S/S AND SOIL COVER
Action-specific	Federal OSHA requirements to protect worker health and safety would be followed during the site work. Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be considered prior to implementation of this alternative.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Provided the stabilized/solidified treatment residuals and the soil covers remain intact, residual risk to human and ecological receptors would be negligible. In the event construction-related invasive activities occur, or burrowing animals penetrate the soil cover, the chemical and physical properties of the treatment residuals would significantly reduce exposure potential via receptor ingestion and/or inhalation of particulates. Because the treatment residuals would be resistant to degradation processes, they would provide long-term protection of groundwater.
Adequacy and Reliability of Controls	Institutional controls would protect the soil covers from invasive activities and restrict residential or public use of the site. Visual inspections would be conducted annually to ensure the integrity of the soil covers. Long-term groundwater monitoring would detect soil contaminants leaching into groundwater.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	S/S would be used to chemically and physically bind soil contaminants into a stabilized/solidified matrix.
Amount Destroyed or Treated	It is estimated that approximately 490,000 cubic yards of contaminated soil would be treated at the Settling Ponds, Spoils Disposal Area, and Final Creek.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	No reduction in contaminant toxicity. Treatment residuals would be resistant to leaching and erosion, preventing the migration of contaminants overland or into groundwater. The volume of contaminated soil would actually increase by up to 50 percent.
Degree to Which Treatment is Irreversible	Treatment is potentially reversible. However, proper maintenance of the soil cover would prevent weathering of the treatment residuals and the release of contaminants.

continued

TABLE 12-7
DETAILED ANALYSIS - ALTERNATIVE SSP-SS7
FINAL CREEK, SETTLING PONDS, AND SPOILS DISPOSAL AREA SOIL

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SSP-SS7 MODIFIED IN SITU S/S AND SOIL COVER
Type and Quantity of Residuals Remaining After Treatment	Treatment residuals would be a granular or monolithic matrix with entrapped contaminants. The residuals would be buried under a minimum of 2 feet of common borrow and topsoil. Assuming excavation and/or the addition of stabilizing/solidifying agents results in a swell factor of 30 percent, 637,000 cubic yards of residuals would remain on site.
Short-term Effectiveness	
Protection of Community During Remedial Action	No risks to the community would be expected during implementation. There are no residences close enough to the site to be affected by noise or dust.
Protection of Workers During Remedial Action	With the use of dust suppression techniques and adherence to general health and safety practices, there would be minimal risk to workers.
Environmental Impacts	The modified in situ S/S alternative may destroy a portion of the burrowing animal habitat by rototilling and placing a 2 foot minimum cover. Appropriate erosion control measures would be employed during implementation to limit environmental impacts.
Time Until Remedial Action Objectives Are Achieved	Treatability testing could potentially take 8-10 weeks. Treatment and cover could take 6 to 10 months.
Implementability	
Ability to Construct and Operate the Technology	Specialized in situ S/S methods have been developed by adapting road construction equipment for that purpose (LaRose, 1993). The even ground surface at the site would be amenable to the use of the equipment. Cover construction can be accomplished using standard construction procedures and conventional earth-moving equipment. Cover repairs would be easily implemented.
Reliability of the Technology	The success of in situ S/S is highly dependent on site- and waste-characteristics. Extensive treatability testing is required. Soil cover is a proven technology for isolating potential receptors from contaminated soil. Annual visual inspections and soil cover repair (if necessary) would ensure that the integrity of the treatment residuals and the soil cover is maintained.
Ease of Undertaking Remedial Actions, if Necessary	Depending upon the physical properties (i.e., granular or monolith) of the treatment residuals, S/S may make future removal actions impractical. If future remedial actions included capping the site to prevent infiltration of precipitation, caps could be constructed over the soil covers.
Ability to Monitor Effectiveness of Remedy	Annual visual inspections would be sufficient for monitoring soil cover effectiveness.



Source: Modified from Tsai, et.al., 1988.

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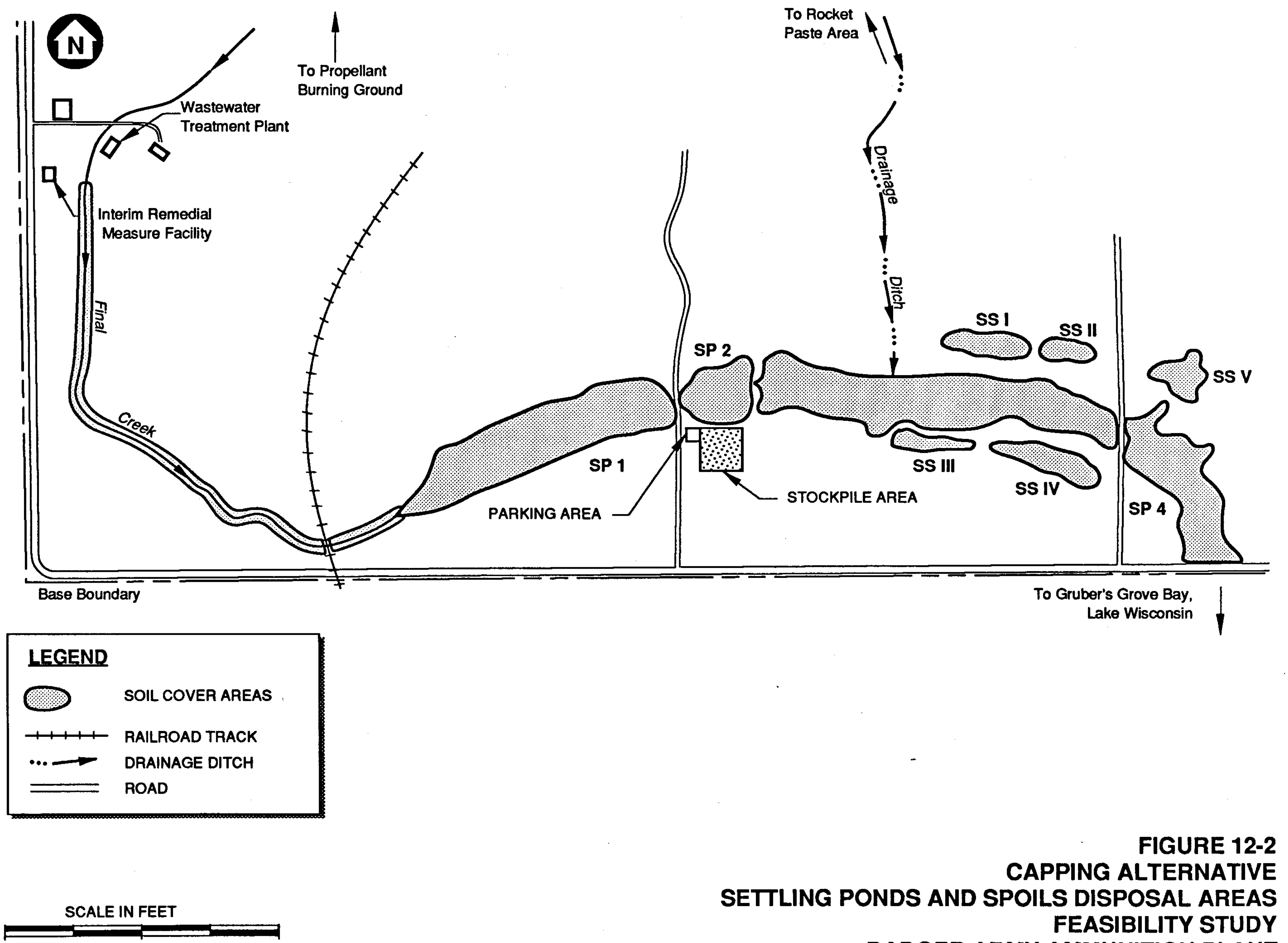
FIGURE 12-1
MINIMAL ACTION ALTERNATIVE
SETTLING PONDS AND SPOILS DISPOSAL AREAS
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.



Source: Modified from Tsai, et.al., 1988.

FIGURE 12-2
CAPPING ALTERNATIVE
SETTLING PONDS AND SPOILS DISPOSAL AREAS
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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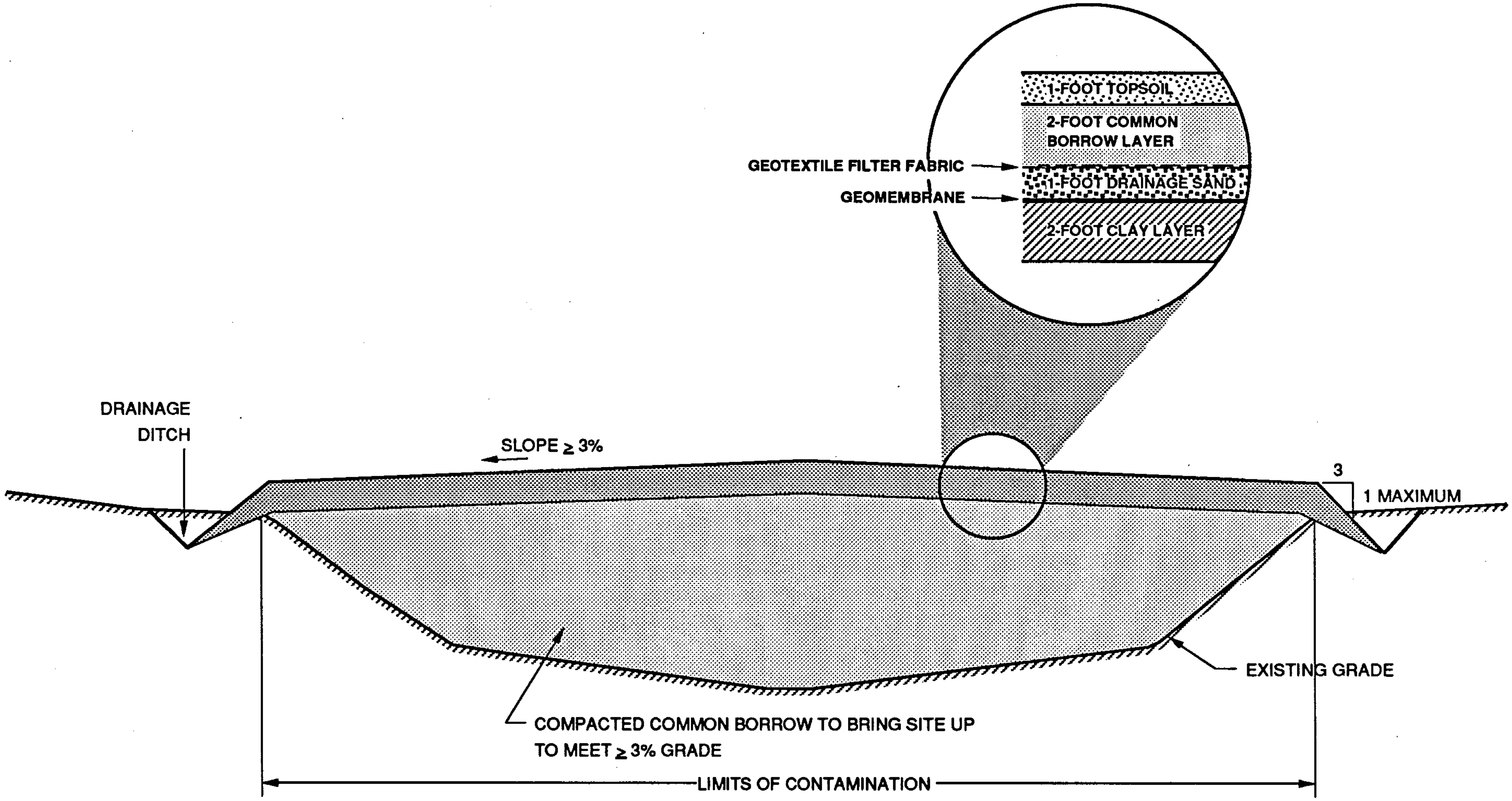

NOT TO SCALE

FIGURE 12-3
TYPICAL CAP CROSS SECTION
SETTLING PONDS, AND SPOILS DISPOSAL AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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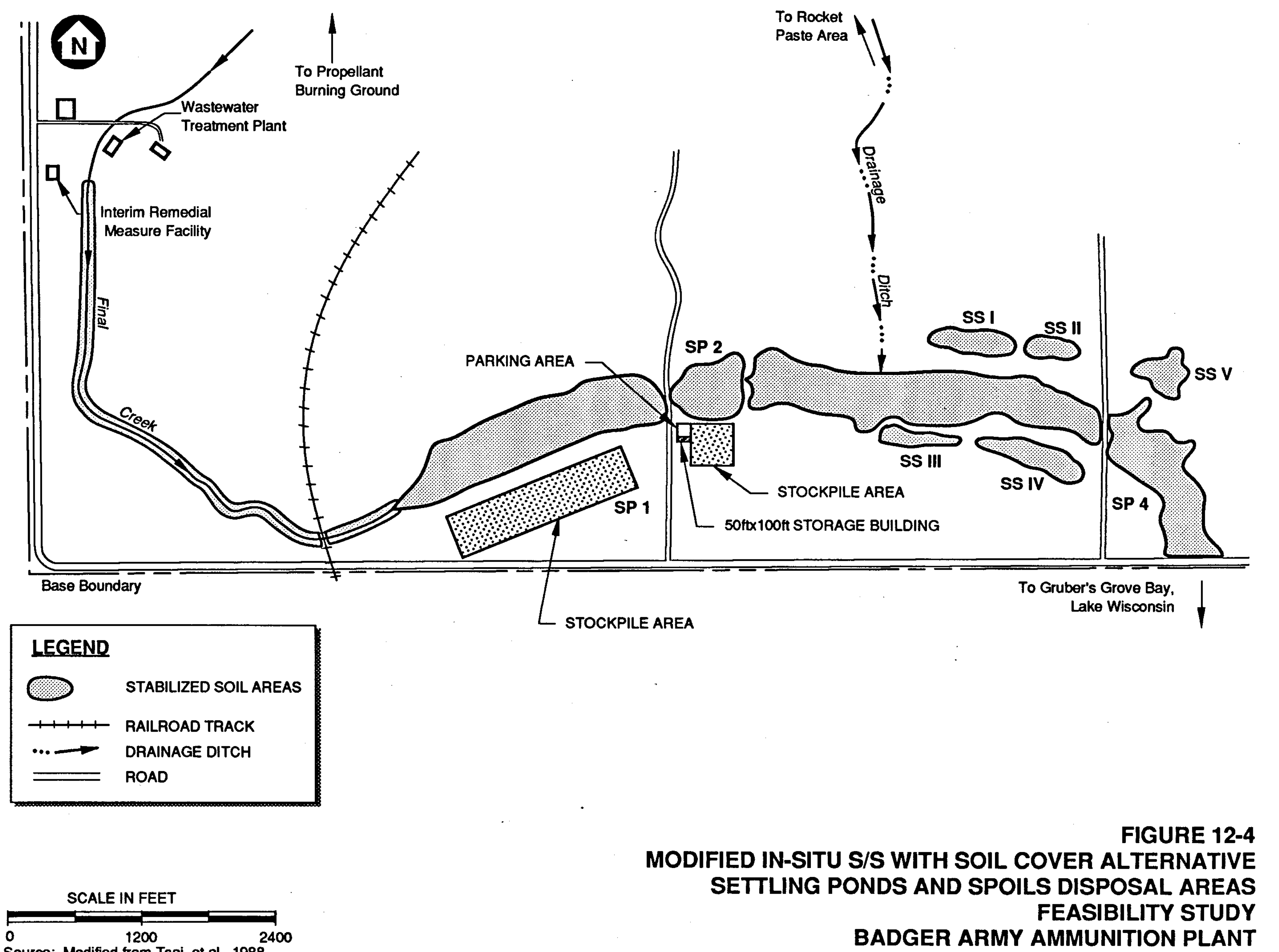

Source: Modified from Tsai, et.al., 1988.

FIGURE 12-4
MODIFIED IN-SITU S/S WITH SOIL COVER ALTERNATIVE
SETTLING PONDS AND SPOILS DISPOSAL AREAS
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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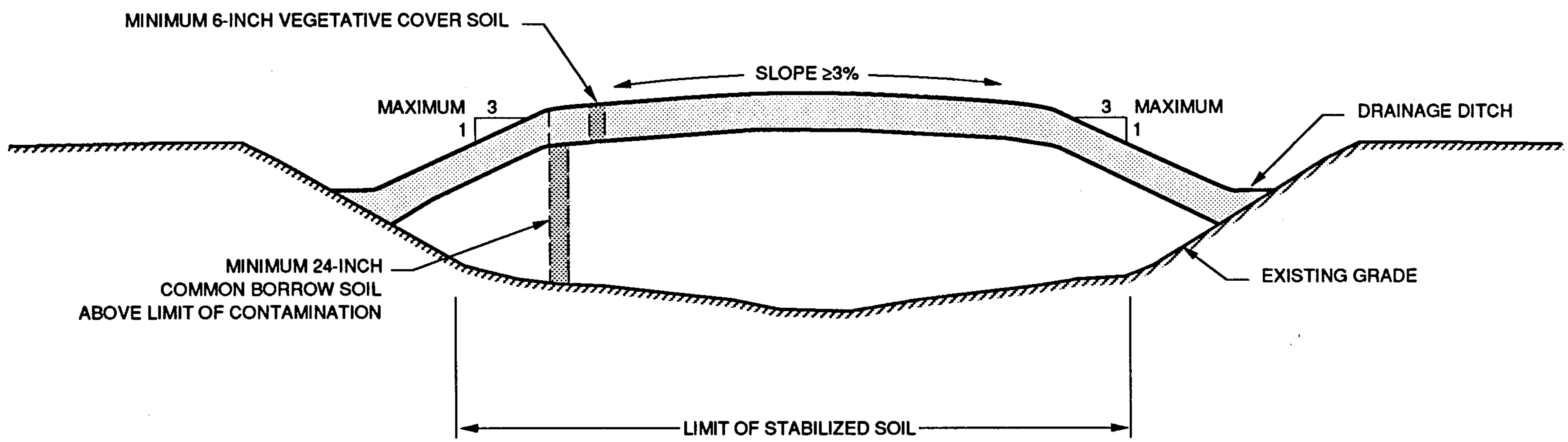

NOT TO SCALE

FIGURE 12-5
TYPICAL MODIFIED IN SITU STABILIZATION WITH COVER CROSS SECTION
SETTLING PONDS, AND SPOILS DISPOSAL AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

9407005D(m)

TABLE 13-1
GROUNDWATER MONITORING PROGRAM
SOUTHERN OFF-POST AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

GROUNDWATER MONITORING WELL LOCATIONS (24)[1]	
SWN 9101 B, C, & D	SWN 9102 C & D
SWN 9103 B, C, D, & E	SWN 9104 C & D
PBN 9101 C	PBM 9001 D
PBM 9002 D	PBN 9102 B & C
PBM 9003 D	PBN 9301 B & C
PBN 9004 B & D	SWN 9105 B, C, & D
PRIVATE WELL LOCATIONS (3)[2]	
Premo	
Schaeffer	
Graf	

Notes:

[1]VOCs, SVOCs, and Metals (filtered) monitored quarterly as described in Modification of Conditional Plan Approval of In-Field Conditions Report (WDNR, 1992).

[2]VOCs, Metals (unfiltered), and Indicator Parameters Monitored Quarterly as Described in In-Field Conditions Report Approval (WDNR, 1987)

TABLE 13-2
COST SUMMARY TABLE
ALTERNATIVE SOPA-GW1: MINIMAL ACTION

FEASIBILITY STUDY
SOUTHERN OFF-POST AREA
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF MINIMAL ACTION		
Education plan preparation	$	50,000
TOTAL DIRECT COST OF MINIMAL ACTION	**$**	**50,000**
INDIRECT COST OF MINIMAL ACTION		
Health and Safety @ 0% of Total Direct Cost	$	0
Legal, Administration, Permitting @ 0% of Total Direct Cost		0
Engineering @ 0% of Total Direct Cost		0
Services During Construction @ 0% of Total Direct Cost		0
TOTAL INDIRECT COST OF MINIMAL ACTION	**$**	**0**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**50,000**
OPERATING AND MAINTENANCE COSTS		
Total cost replacement wells	$	22,000
Total present worth of replacement wells in year 16 @ 5%	$	10,000
Total Annual Operating and Maintenance Costs	$	184,000
Total present worth of annual O&M costs (5% for 30 years)	$	2,829,000
TOTAL PRESENT WORTH OF O&M COSTS	**$**	**2,839,000**
TOTAL COST FOR GW-1 MINIMAL ACTION	**$**	**2,889,000**

TABLE 13-3
DETAILED ANALYSIS - ALTERNATIVE SOPA-GW1
SOUTHERN OFF-POST AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SOPA-GW1 - MINIMAL ACTION
Overall Protection of Human Health and the Environment	
Human Health Protection	Under a minimal action scenario, the public would continue to be potentially exposed to contaminated drinking water. However, this alternative would achieve the remedial action objective by reducing existing human receptor (i.e., farm worker) exposure to contaminated groundwater. Groundwater monitoring would detect changes in contaminant distribution potentially affecting public and/or private wells. Changes in contaminant distribution would be mitigated by actions implemented per the Off-Post Contingency Plan.
Environmental Protection	Groundwater contaminants are not expected to bioaccumulate in irrigated crops; therefore, there is no threat to the environment.
Compliance with ARARs	
Chemical-specific	WPALs would be achieved in approximately 66 years (estimated using USEPA batch flushing model) after implementation of the BAAP Control Wells.
Location-specific	Location-specific ARARs do not apply to this alternative.
Action-specific	Action-specific ARARs do not apply to this alternative because no action would be taken.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	Interception of the contaminant plume at the southern BAAP boundary would result in eventual decreases in contaminant concentrations and residual risk downgradient (i.e., Southern Off-Post Area) of BAAP.
Adequacy and Reliability of Controls	Not Applicable. No controls would be used in this alternative.
Reduction of Toxicity, Mobility, or Volume through Treatment	
Treatment Process Used and Materials Treated	Not Applicable. No treatment is used in this alternative.
Amount Destroyed or Treated	No contamination is destroyed or treated.
Degree of Expected Reductions of Toxicity, Mobility, or Volume through Treatment	No reduction of toxicity, mobility, or volume through treatment because treatment is not used.
Degree to Which Treatment is Irreversible	No treatment is used.
Type and Quantity of Residuals Remaining After Treatment	No treatment is used.
Short-term Effectiveness	
Protection of Community during Remedial Action	No adverse or beneficial impact to the community would occur because no remedial actions would be implemented.
Worker Protection during Remedial Action	No adverse worker impacts because no remedial actions would be implemented.

(continued)

TABLE 13-3
DETAILED ANALYSIS - ALTERNATIVE SOPA-GW1
SOUTHERN OFF-POST AREA

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SOPA-GW1 - MINIMAL ACTION
Environmental Impacts	No direct or indirect short-term adverse ecological effects would occur because no remedial actions would be implemented.
Time until Remedial Action Objectives are Achieved	The remedial action objectives would be achieved with the implementation of the institutional controls. The aquifer would remain contaminated until natural attenuation and degradation processes reduce contaminant concentrations.
Implementability	
Ability to Construct and Operate the Technology	No construction would occur.
Reliability of Technology	No technologies would be used.
Ease of Undertaking Additional Remedial Action, if Necessary	Minimal action would not limit or interfere with the ability to perform future remedial actions.
Ability to Monitor Effectiveness of Remedy	Monitoring program can be implemented using existing monitoring wells.
Ability to Obtain Approvals and Coordinate with other Agencies	No permits would be required.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Not required.
Availability of Necessary Equipment and Specialists	No equipment would be required.
Availability of Technology	No technologies would be used.
Cost	
Capital Cost	$50,000
Present Worth of Operation and Maintenance Cost	$2,839,000
Net Present Worth Cost	$2,889,000

Notes:

ARARs = Applicable or Relevant and Appropriate Requirements
PRG = Preliminary Remediation Goal

TABLE 13-4
TREATMENT FACILITY INFLUENT CONCENTRATIONS AND SURFACE WATER DISCHARGE LIMITS
GROUNDWATER EXTRACTION SCENARIO 1
SOUTHERN OFF-POST AREA

FEASIBILITY STUDY REPORT
BADGER ARMY AMMUNITION PLANT

COMPOUND	MAXIMUM CONCENTRATION DETECTED[1] ($\mu g/\ell$)	ASSUMED CONCENTRATIONS IN INFLUENT FROM PROPOSED CONTROL WELLS[2] ($\mu g/\ell$)	ESTIMATED SURFACE WATER DISCHARGE LIMIT[3] ($\mu g/\ell$)
OPCW-1 through OPCW-6			
CCL4	97.0	10.0	<1
CHCL3	8.25	2.0	<1
TRCLE	2.44	1.0	<1

Notes:

1 Maximum concentration detected in the Final RI Report (ABB-ES, 1993a) base boundary monitoring wells.
2 Approximate concentrations calculated from base boundary monitoring well concentrations.
3 Estimated discharge limits assume 99% removal of organic contaminants is required.

TABLE 13-5
TREATMENT FACILITY INFLUENT CONCENTRATIONS AND SURFACE WATER DISCHARGE LIMITS
GROUNDWATER EXTRACTION SCENARIO 2
SOUTHERN OFF-POST AREA

FEASIBILITY STUDY REPORT
BADGER ARMY AMMUNITION PLANT

COMPOUND	MAXIMUM CONCENTRATION DETECTED[1] ($\mu g/\ell$)	ASSUMED CONCENTRATIONS IN INFLUENT FROM PROPOSED CONTROL WELLS[2] ($\mu g/\ell$)	ESTIMATED SURFACE WATER DISCHARGE LIMIT[3] ($\mu g/\ell$)
OPCW-1 through OPCW-6			
CCL4	10.8	5.0	<1
CHCL3	1.31	1.0	<1
TRCLE	0.425	1.0	<1
OPCW-7 through OPCW-12			
CCL4	97.0	10.0	<1
CHCL3	8.25	2.0	<1
TRCLE	2.44	1.0	<1

Notes:

1 Maximum concentrations detected in the Final RI Report (ABB-ES, 1993a) in upgradient monitoring wells prior to the next row of extraction wells.

2 Approximate concentrations calculated from base boundary monitoring well concentrations.

3 Estimated discharge limits assume 99% removal of organic contaminants is required.

TABLE 13-6
TREATMENT FACILITY INFLUENT CONCENTRATIONS AND SURFACE WATER DISCHARGE LIMITS
GROUNDWATER EXTRACTION SCENARIO 3
SOUTHERN OFF-POST AREA

FEASIBILITY STUDY REPORT
BADGER ARMY AMMUNITION PLANT

COMPOUND	MAXIMUM CONCENTRATION DETECTED[1] (μg/ℓ)	ASSUMED CONCENTRATIONS IN INFLUENT FROM PROPOSED CONTROL WELLS[2] (μg/ℓ)	ESTIMATED SURFACE WATER DISCHARGE LIMIT[3] (μg/ℓ)
OPCW-1 through OPCW-6			
CCL4	3.53	2.0	<1
CHCL3	0.594	1.0	<1
TRCLE	ND	1.0	<1
OPCW-7 through OPCW-12			
CCL4	10.8	6.0	<1
CHCL3	1.31	1.0	<1
TRCLE	0.425	1.0	<1
OPCW-13 through OPCW-18			
CCL4	10.8	5.0	<1
CHCL3	1.31	1.0	<1
TRCLE	0.425	1.0	<1
OPCW-19 through OPCW-24			
CCL4	97.0	10.0	<1
CHCL3	8.25	2.0	<1
TRCLE	2.44	1.0	<1

Notes:

1 Maximum concentrations detected in the Final RI Report (ABB-ES, 1993a) in upgradient monitoring wells at or prior to the next row of extraction wells.
2 Approximate concentrations calculated from base boundary monitoring well concentrations.
3 Estimated discharge limits assume 99% removal of organic contaminants is required.

ND = Not detected

TABLE 13-7
GROUNDWATER TREATMENT SYSTEM
SAMPLING AND ANALYSIS PROGRAM

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

COMPOUND	USEPA METHOD
CCL4	8240
CHCL3	8240
TRCLE	8240
CD	6010
PB	7421
MN	6010

TABLE 13-8
COST SUMMARY TABLE
ALTERNATIVE SOPA-GW2: AIR STRIPPING - WITH GROUNDWATER EXTRACTION SCENARIO 1

FEASIBILITY STUDY
SOUTHERN OFF-POST AREA
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF AIR STRIPPING WITH GROUNDWATER EXTRACTION SCENARIO 1		
Site Preparation and Mob/Demob	$	399,000
Groundwater Extraction Pumps & Piping		2,042,000
Treatment Plant Building		437,000
Treatment Plant Process Equipment		618,000
Electrical & Instrumentation		1,014,000
Gravity Discharge		346,000
Education Plan Preparation		50,000
TOTAL DIRECT COST OF AIR STRIPPING WITH GWE SCENARIO 1	$	4,906,000
INDIRECT COST OF AIR STRIPPING WITH GROUNDWATER EXTRACTION SCENARIO 1		
Health and Safety @ 5% of Total Direct Cost	$	245,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		245,000
Engineering @ 10% of Total Direct Cost		491,000
Services During Construction @ 10% of Total Direct Cost		491,000
TOTAL INDIRECT COST OF AIR STRIPPING WITH GWE SCENARIO 1	$	1,472,000
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$	6,378,000
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	729,000
TOTAL PRESENT WORTH OF O&M COSTS	$	13,837,000
TOTAL COST OF AIR STRIPPING WITH GROUNDWATER EXTRACTION SCENARIO 1	$	20,215,000

TABLE 13-9
COST SUMMARY TABLE
ALTERNATIVE SOPA-GW2: AIR STRIPPING - WITH GROUNDWATER EXTRACTION SCENARIO 2

FEASIBILITY STUDY
SOUTHERN OFF-POST AREA
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF AIR STRIPPING WITH GROUNDWATER EXTRACTION SCENARIO 2		
Site Preparation and Mob/Demob	$	480,000
Groundwater Extraction Pumps & Piping		3,863,000
Treatment Plant Building		671,000
Treatment Plant Process Equipment		1,236,000
Electrical & Instrumentation		1,611,000
Gravity Discharge		670,000
Education Plan Preparation		50,000
TOTAL DIRECT COST OF AIR STRIPPING WITH GWE SCENARIO 2	**$**	**8,581,000**
INDIRECT COST OF AIR STRIPPING WITH GROUNDWATER EXTRACTION SCENARIO 2		
Health and Safety @ 5% of Total Direct Cost	$	429,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		429,000
Engineering @ 10% of Total Direct Cost		858,000
Services During Construction @ 10% of Total Direct Cost		858,000
TOTAL INDIRECT COST OF AIR STRIPPING WITH GWE SCENARIO 2	**$**	**2,574,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**11,155,000**
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	1,138,000
TOTAL PRESENT WORTH OF O&M COSTS	**$**	**18,428,000**
TOTAL COST FOR SOPA-GW2: AIR STRIPPING WITH GROUNDWATER EXTRACTION SCENARIO 2	**$**	**29,583,000**

TABLE 13-10
COST SUMMARY TABLE
ALTERNATIVE SOPA-GW2: AIR STRIPPING - WITH GROUNDWATER EXTRACTION SCENARIO 3

FEASIBILITY STUDY
SOUTHERN OFF-POST AREA
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF AIR STRIPPING WITH GROUNDWATER EXTRACTION SCENARIO 3		
Site Preparation and Mob/Demob	$	578,000
Groundwater Extraction Pumps & Piping		8,150,000
Treatment Plant Building		999,000
Treatment Plant Process Equipment		2,382,000
Electrical & Instrumentation		3,419,000
Gravity Discharge		856,000
Education Plan Preparation		50,000
TOTAL DIRECT COST OF AIR STRIPPING WITH GWE SCENARIO 3	$	16,434,000
INDIRECT COST OF AIR STRIPPING WITH GROUNDWATER EXTRACTION SCENARIO 3		
Health and Safety @ 5% of Total Direct Cost	$	822,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		822,000
Engineering @ 10% of Total Direct Cost		1,643,000
Services During Construction @ 10% of Total Direct Cost		1,643,000
TOTAL INDIRECT COST OF AIR STRIPPING WITH GWE SCENARIO 3	$	4,930,000
TOTAL CAPITAL (DIRECT + INDIRECT) COST	$	21,364,000
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	1,905,000
TOTAL PRESENT WORTH OF O&M COSTS	$	21,477,000
TOTAL COST FOR SOPA-GW2: AIR STRIPPING WITH GROUNDWATER EXTRACTION SCENARIO 3	$	42,841,000

TABLE 13-11
DETAILED ANALYSIS - ALTERNATIVE SOPA-GW2
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SOPA-GW2 AIR STRIPPING
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objectives. This alternative would prevent further migration of contaminated groundwater and reduce contaminant concentrations in groundwater to acceptable levels.
Environmental Protection	No ecological risks associated with contaminated groundwater.
Compliance with ARARs	
Chemical-specific	The WPAL (WAC Chapter NR 140.10, Table 1) for CCL4, CHCL3, TRCLE, CD, and PB would eventually be achieved in the aquifer. Secondary drinking water standards for MN would eventually be achieved in the aquifer. Each of the three groundwater extraction scenarios would require different periods of time to comply with the WPALs in the aquifer. A WPDES (WAC Chapter NR 205) permit issued for discharge of treated groundwater to the Wisconsin River will specify individual discharge limits for each of the groundwater contaminants. It is presumed that this alternative is capable of achieving those limits.
Location-specific	Construction of the effluent discharge pipe would impact the shoreline of the Wisconsin River, and would require permitting through Wisconsin Shoreline Management Program.
Action-specific	Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards. Air emissions from the air stripper(s) would be limited per a permit issued in accordance with WAC Chapter NR 406. An emission limit for each potential air contaminant is identified in WAC Chapter NR 445. In addition, WAC Chapter NR 419 identifies a daily limit for total VOCs emitted from a facility. It is presumed that emission treatment systems associated with the air strippers would meet emission limits.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be implemented prior to implementing this alternative.

(continued)

TABLE 13-11
DETAILED ANALYSIS - ALTERNATIVE SOPA-GW2
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SOPA-GW2 AIR STRIPPING
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	This alternative would be implemented to comply with WPALs and secondary drinking water standards. The standards were developed to minimize risk; therefore, the magnitude of the residual risk would be minimal. Because the source of the Southern Off-Post Area contaminant plume will be intercepted at the base boundary, this alternative would result in eventual decreases in contaminant concentrations.
Adequacy and Reliability of Controls	Because the source of the Off-Post Area contamination would be removed, long-term monitoring after achieving contaminant concentrations below the WPALs would not be required.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Air stripper(s) in the new treatment facility (i.e., air stripping treatment facility) would be used for primary treatment of CCL4, CHCL3, and TRCLE. Thermal reactivation of spent vapor-phase carbon would destroy adsorbed contaminants. Treatment of PB, CD, and MN is not expected to be necessary in order to meet surface water discharge limits.
Amount Destroyed or Treated	Groundwater Extraction Scenario 1. During the first year of operation, approximately 53 pounds of organic contaminants would be adsorbed by vapor-phase carbon and destroyed by thermal regeneration. Contaminant travel time from the base boundary to extraction well group OPCW-1 through OPCW-6 (see Figure 13-2) would be approximately 14 years. During this interim duration of time contaminant concentrations would be expected to increase and level off at these extraction wells. For the remaining period of groundwater extraction, contaminant concentrations would decrease as uncontaminated groundwater flushes the aquifer.

(continued)

TABLE 13-11
DETAILED ANALYSIS - ALTERNATIVE SOPA-GW2
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SOPA-GW2 AIR STRIPPING
	Groundwater Extraction Scenario 2. During the first year of operation, approximately 158 pounds of organic contaminants would be adsorbed by vapor-phase carbon and destroyed by thermal regeneration. Contaminant travel time from the base boundary to extraction well group OPCW-7 through OPCW-12 (see Figure 13-3) would be approximately 8 years. Contaminant travel time from extraction well group OPCW-7 through OPCW-12 to well group OPCW-1 through OPCW-6 would be approximately 6 years. During this interim, contaminant concentrations would be expected to increase and level off at these extraction wells. For the remaining period of groundwater extraction, contaminant concentrations would decrease as uncontaminated groundwater flushes the aquifer.
	Groundwater Extraction Scenario 3. During the first year of operation, approximately 425 pounds of organic contaminants would be adsorbed by vapor-phase carbon and destroyed by thermal regeneration. Contaminant travel times from the base to extraction well group OPCW-19 through OPCW-24, from well group OPCW-19 through OPCW-24 to well group OPCW-7 through OPCW-12, from well group OPCW-7 through OPCW-12 to well group OPCW-13 through OPCW-18, and from wells OPCW-13 through OPCW-18 to well group OPCW-1 through OPCW-6, would be approximately 3.5, 4.5, 3, and 3 years, respectively. During this interim, contaminant concentrations would be expected to increase and level off at these extraction wells. For the remaining period of groundwater extraction, contaminant concentrations would decrease as uncontaminated groundwater flushes the aquifer.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	The WPDES permit issued for discharge of treated groundwater is expected to require a treatment system removal efficiency of at least 99 percent. Groundwater contaminants adsorbed to the spent carbon would be destroyed during thermal reactivation.
Degree to Which Treatment is Irreversible	Groundwater contaminants would be destroyed during thermal reactivation of spent carbon.
Type and Quantity of Residuals Remaining After Treatment	Approximately 24,000, 90,000, and 96,000 lbs of spent vapor-phase carbon for groundwater extraction Scenarios 1, 2, and 3, respectively, would be generated in the new facility every 10 years. Assuming complete destruction of contaminants in the spent carbon during thermal reactivation, no residuals would remain.

(continued)

TABLE 13-11
DETAILED ANALYSIS - ALTERNATIVE SOPA-GW2
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SOPA-GW2 AIR STRIPPING
Short-term Effectiveness	
Protection of Community During Remedial Action	Implementation of the groundwater extraction and treatment alternative would not result in any significant short-term adverse impacts to the public. Contaminants in air stripper emissions would be treated with vapor-phase carbon. Trace quantities may be released into the atmosphere but would be well within safe limits.
Protection of Workers During Remedial Action	During construction, adherence to general health and safety practices would minimize risk to workers.
Environmental Impacts	Adverse impacts to the environment may occur during construction of extraction wells and influent and effluent pipelines. Some trees may have to be removed for implementation of this alternative.
Time Until Remedial Action Objectives Are Achieved	Remedial objectives would be achieved at the onset of implementation of the institutional controls portion of this alternative. After extraction and treatment implementation, an estimated 61, 34, and 17 years for groundwater extraction Scenarios 1, 2, and 3, respectively, would be required to achieve WPALs in the Southern Off-Post Area contaminant plume. An estimated 2 years for design and construction should be added to the above cleanup times.
Implementability	
Ability to Construct and Operate the Technology	Construction of the new facility would not be difficult. Air stripping operating practices would include adjustment and monitoring of water and airflow rates, as well as possible acid treatments to prevent scaling buildup. Carbon adsorption (i.e., vapor-phase) system operating practices would include replacing carbon at breakthrough.
Reliability of the Technology	Air stripping and vapor-phase carbon adsorption are proven technologies for removing organic contaminants from groundwater. The aqueous-phase carbon adsorption system and the air stripper system in the existing IRM facility have successfully operated for more than three years treating Propellant Burning Ground groundwater.
Ease of Undertaking Additional Remedial Action, if Necessary	This alternative would not preclude or hinder any future remedial activities conducted on the Southern Off-Post Area contaminant plume, if necessary.
Ability to Monitor Effectiveness of Remedy	The effectiveness of the treatment system would be monitored by analysis of samples collected bi-weekly from treatment systems influent and effluent. Aquifer cleanup can be monitored via the groundwater monitoring program.

(continued)

TABLE 13-11
DETAILED ANALYSIS - ALTERNATIVE SOPA-GW2
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SOPA-GW2 AIR STRIPPING
Ability to Obtain Approvals and Coordinate with Other Agencies	Obtaining a WPDES permit for the discharge of treated groundwater to the Wisconsin River is not expected to be difficult. The existing IRM facility currently operates under a WPDES permit. Sampling and analysis of air stripper emissions may have to be conducted prior to receiving an air permit. Permitting under the Wisconsin Shoreline Management Program would be required for effluent discharge pipe construction. It is assumed that affected property owners will be cooperative during negotiations for easements.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Facilities which have sufficient capacity for reactivation of spent carbon are available.
Availability of Necessary Equipment and Specialists	Air stripping and vapor-phase carbon adsorption equipment and expertise is available from several vendors.
Availability of Technology	Air stripping and vapor-phase carbon adsorption technology for the treatment of groundwater contaminated with chlorinated compounds is available.
Costs	
Capital Cost	
<u>Air Stripping - Groundwater Extraction Scenario 1</u>	$6,378,000
<u>Air Stripping - Groundwater Extraction Scenario 2</u>	$11,155,000
<u>Air Stripping - Groundwater Extraction Scenario 3</u>	21,364,000
Present Worth of Operation and Maintenance Cost	
<u>Air Stripping - Groundwater Extraction Scenario 1</u>	$13,837,000
<u>Air Stripping - Groundwater Extraction Scenario 2</u>	$18,428,000
<u>Air Stripping - Groundwater Extraction Scenario 3</u>	$21,477,000

(continued)

TABLE 13-11
DETAILED ANALYSIS - ALTERNATIVE SOPA-GW2
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SOPA-GW2 AIR STRIPPING
Net Present Worth Cost	
Air Stripping - Groundwater Extraction Scenario 1	$20,215,000
Air Stripping - Groundwater Extraction Scenario 2	$29,583,000
Air Stripping - Groundwater Extraction Scenario 3	$42,841,000

TABLE 13-12
COST SUMMARY TABLE
ALTERNATIVE SOPA-GW3: CARBON ADSORPTION
WITH GROUNDWATER EXTRACTION SCENARIO 1

FEASIBILITY STUDY
SOUTHERN OFF-POST AREA
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF CARBON ADSORPTION WITH GROUNDWATER EXTRACTION SCENARIO 1		
Site Preparation and Mob/Demob	$	399,000
Groundwater Extraction Pumps & Piping		2,042,000
Treatment Plant Building		412,000
Treatment Plant Process Equipment		726,000
Electrical & Instrumentation		1,008,000
Gravity Discharge		346,000
Education Plan Preparation		50,000
TOTAL DIRECT COST OF CARBON ADSORPTION WITH GWE SCENARIO 1	**$**	**4,983,000**
INDIRECT COST OF CARBON ADSORPTION WITH GROUNDWATER EXTRACTION SCENARIO 1		
Health and Safety @ 5% of Total Direct Cost	$	249,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		249,000
Engineering @ 10% of Total Direct Cost		498,000
Services During Construction @ 10% of Total Direct Cost		498,000
TOTAL INDIRECT COST OF CARBON ADSORPTION WITH GWE SCENARIO 1	**$**	**1,494,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**6,477,000**
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	822,000
TOTAL PRESENT WORTH OF O&M COSTS	**$**	**15,602,000**
TOTAL COST OF CARBON ADSORPTION WITH GROUNDWATER EXTRACTION SCENARIO 1	**$**	**22,079,000**

TABLE 13-13
COST SUMMARY TABLE
ALTERNATIVE SOPA-GW3: CARBON ADSORPTION WITH GROUNDWATER EXTRACTION SCENARIO 2

FEASIBILITY STUDY
SOUTHERN OFF-POST AREA
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF CARBON ADSORPTION WITH GROUNDWATER EXTRACTION SCENARIO 2		
Site Preparation and Mob/Demob	$	480,000
Groundwater Extraction Pumps & Piping		3,863,000
Treatment Plant Building		724,000
Treatment Plant Process Equipment		1,458,000
Electrical & Instrumentation		1,602,000
Gravity Discharge		670,000
Education Plan Preparation		50,000
TOTAL DIRECT COST OF CARBON ADSORPTION WITH GWE SCENARIO 2	**$**	**8,847,000**
INDIRECT COST OF CARBON ADSORPTION WITH GROUNDWATER EXTRACTION SCENARIO 2		
Health and Safety @ 5% of Total Direct Cost	$	442,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		442,000
Engineering @ 10% of Total Direct Cost		885,000
Services During Construction @ 10% of Total Direct Cost		885,000
TOTAL INDIRECT COST OF CARBON ADSORPTION WITH GWE SCENARIO 2	**$**	**2,654,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**11,501,000**
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	1,335,000
TOTAL PRESENT WORTH OF O&M COSTS	**$**	**21,618,000**
TOTAL COST FOR SOPA-GW3: CARBON ADSORPTION WITH GROUNDWATER EXTRACTION SCENARIO 2	**$**	**33,119,000**

TABLE 13-14
COST SUMMARY TABLE
ALTERNATIVE SOPA-GW3: CARBON ADSORPTION WITH GROUNDWATER EXTRACTION SCENARIO 3

FEASIBILITY STUDY
SOUTHERN OFF-POST AREA
BADGER ARMY AMMUNITION PLANT

ITEM		TOTAL COST
DIRECT COST OF CARBON ADSORPTION WITH GROUNDWATER EXTRACTION SCENARIO 3		
Site Preparation and Mob/Demob	$	578,000
Groundwater Extraction Pumps & Piping		8,150,000
Treatment Plant Building		1,283,000
Treatment Plant Process Equipment		2,742,000
Electrical & Instrumentation		3,411,000
Gravity Discharge		856,000
Education Plan Preparation		50,000
TOTAL DIRECT COST OF CARBON ADSORPTION WITH GWE SCENARIO 3	**$**	**17,070,000**
INDIRECT COST OF CARBON ADSORPTION WITH GROUNDWATER EXTRACTION SCENARIO 3		
Health and Safety @ 5% of Total Direct Cost	$	854,000
Legal, Administration, Permitting @ 5% of Total Direct Cost		854,000
Engineering @ 10% of Total Direct Cost		1,707,000
Services During Construction @ 10% of Total Direct Cost		1,707,000
TOTAL INDIRECT COST OF CARBON ADSORPTION WITH GWE SCENARIO 3	**$**	**5,122,000**
TOTAL CAPITAL (DIRECT + INDIRECT) COST	**$**	**22,192,000**
OPERATING AND MAINTENANCE COSTS		
Total Annual Operating and Maintenance Costs	$	2,304,000
TOTAL PRESENT WORTH OF O&M COSTS	**$**	**25,975,000**
TOTAL COST FOR SOPA-GW3: CARBON ADSORPTION WITH GROUNDWATER EXTRACTION SCENARIO 3	**$**	**48,167,000**

TABLE 13-15
DETAILED ANALYSIS - ALTERNATIVE SOPA-GW3
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SOPA-GW3 CARBON ADSORPTION
Overall Protection of Human Health and the Environment	
Human Health Protection	Achieves remedial action objectives. This alternative would prevent further migration of contaminated groundwater and reduce contaminant concentrations in groundwater to acceptable levels.
Environmental Protection	No ecological risks associated with contaminated groundwater.
Compliance with ARARs	
Chemical-specific	The WPAL (WAC Chapter NR 140.10, Table 1) for CCL4, CHCL3, TRCLE, CD, and PB would eventually be achieved in the aquifer. Secondary drinking water standards for MN would eventually be achieved in the aquifer. Each of the three groundwater extraction scenarios would require different periods of time to comply with the WPALs in the aquifer. A WPDES (WAC Chapter NR 205) permit issued for discharge of treated groundwater to the Wisconsin River will specify individual discharge limits for each of the groundwater contaminants. It is presumed that this alternative is capable of achieving those limits.
Location-specific	Construction of the effluent discharge pipe would impact the shoreline of the Wisconsin River, and would require permitting through Wisconsin Shoreline Management Program (NR 115).
Action-specific	Fugitive particulate emissions generated during site work are substantively subject to Wisconsin Particulate and Sulfur Emission Rules (WAC, Chapter NR 415) and General and Portable Sources Air Pollution Control Rules; Ambient Air Quality Standards (WAC, Chapter NR 404). It is assumed that dust suppression techniques and other preventative measures would ensure compliance with particulate emission standards.
Other Criteria, Advisories, and Guidances	It is presumed that relevant criteria, advisories, and guidances would be implemented prior to implementing this alternative.
Long-term Effectiveness and Permanence	
Magnitude of Residual Risk	This alternative would be implemented to comply with WPALs and secondary drinking water standards. The standards were developed to minimize risk; therefore, the magnitude of the residual risk would be minimal. Because the source of the Southern Off-Post Area contaminant plume will be intercepted at the base boundary, this alternative would result in eventual decreases in contaminant concentrations.

(continued)

TABLE 13-15
DETAILED ANALYSIS - ALTERNATIVE SOPA-GW3
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SOPA-GW3 CARBON ADSORPTION
Adequacy and Reliability of Controls	Because the source of the Off-Post Area contamination would be removed, long-term monitoring after achieving contaminant concentrations below the WPALs for groundwater would not be required.
Reduction of Toxicity, Mobility, and Volume	
Treatment Process Used and Materials Treated	Carbon Adsorption in the new treatment facility (i.e., carbon adsorption treatment facility) would be used for primary treatment of CCL4, CHCL3, and TRCLE. Thermal reactivation of spent aqueous-phase carbon would destroy adsorbed contaminants. Treatment of PB, CD, and MN is not expected to be necessary in order to meet surface water discharge limits.
Amount Destroyed or Treated	Groundwater Extraction Scenario 1. During the first year of operation, approximately 53 pounds of organic contaminants would be adsorbed by aqueous-phase carbon and destroyed by thermal regeneration. Contaminant travel time from the base boundary to extraction well group OPCW-1 through OPCW-6 (see Figure 13-2) would be approximately 14 years. During this interim, contaminant concentrations would be expected to increase and level off at these extraction wells. For the remaining period of groundwater extraction, contaminant concentrations would decrease as uncontaminated groundwater flushes the aquifer. Groundwater Extraction Scenario 2. During the first year of operation, approximately 158 pounds of organic contaminants would be adsorbed by aqueous-phase carbon and destroyed by thermal regeneration. Contaminant travel time from the base boundary to extraction well group OPCW-7 through OPCW-12 (see Figure 13-3) would be approximately 8 years. Contaminant travel time from extraction well group OPCW-7 through OPCW-12 to well group OPCW-1 through OPCW-6 would be approximately 6 years. During this interim, contaminant concentrations would be expected to increase and level off at these extraction wells. For the remaining period of groundwater extraction, contaminant concentrations would decrease as uncontaminated groundwater flushes the aquifer.

(continued)

TABLE 13-15
DETAILED ANALYSIS - ALTERNATIVE SOPA-GW3
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SOPA-GW3 CARBON ADSORPTION
	Groundwater Extraction Scenario 3. During the first year of operation, approximately 425 pounds of organic contaminants would be adsorbed by aqueous-phase carbon and destroyed by thermal regeneration. Contaminant travel times from the base to extraction well group OPCW-19 through OPCW-24, from well group OPCW-19 through OPCW-24 to well group OPCW-7 through OPCW-12, from well group OPCW-7 through OPCW-12 to OPCW-13 through OPCW-18, and from well group OPCW-13 through OPCW-18 to well group OPCW-1 through OPCW-6, would be approximately 3.5, 4.5, 3, and 3 years, respectively. During this interim, contaminant concentrations would be expected to increase and level off at these extraction wells. For the remaining period of groundwater extraction, contaminant concentrations would decrease as uncontaminated groundwater flushes the aquifer.
Degree of Expected Reductions of Toxicity, Mobility, and Volume	The WPDES permit issued for discharge of treated groundwater is expected to require a treatment system removal efficiency of at least 99 percent. Groundwater contaminants adsorbed to the spent carbon would be destroyed during thermal reactivation.
Degree to Which Treatment is Irreversible	Groundwater contaminants would be destroyed during thermal reactivation of spent carbon.
Type and Quantity of Residuals Remaining After Treatment	Approximately 120,000, 240,000, and 480,000 lbs of spent aqueous-phase carbon for groundwater extraction Scenarios 1, 2, and 3, respectively, would be generated in the new facility every year. Assuming complete destruction of contaminants in the spent carbon during thermal reactivation, no residuals would remain.

(continued)

TABLE 13-15
DETAILED ANALYSIS - ALTERNATIVE SOPA-GW3
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SOPA-GW3 CARBON ADSORPTION
Short-term Effectiveness	
Protection of Community During Remedial Action	Implementation of the groundwater extraction and treatment alternative would not result in any significant short term adverse impacts to the public.
Protection of Workers During Remedial Action	During construction, adherence to general health and safety practices would minimize risk to workers.
Environmental Impacts	Adverse impacts to the environment may occur during construction of extraction wells and influent and effluent pipelines. Some trees may have to be removed for implementation of this alternative.
Time Until Remedial Action Objectives Are Achieved	Remedial objectives would be achieved at the onset of implementation of the institutional controls portion of this alternative. After extraction and treatment implementation, an estimated 61, 34, and 17 years for groundwater extraction Scenarios 1, 2, and 3, respectively, would be required to achieve WPALs in the Southern Off-Post Area contaminant plume. An estimated 2 years for design and construction should be added to the above cleanup times.
Implementability	
Ability to Construct and Operate the Technology	Construction of the new facility would not be difficult. Carbon adsorption (i.e., aqueous-phase) system operating practices would include replacing carbon at breakthrough in the lead vessel.
Reliability of the Technology	Carbon adsorption is a proven technology for removing organic contaminants from groundwater. The existing IRM facility (and associated carbon adsorption system) has been successfully operated for more than three years treating Propellant Burning Ground groundwater. Monitoring for contaminant breakthrough between the carbon vessels would ensure that WPDES discharge limits are not exceeded.
Ease of Undertaking Additional Remedial Action, if Necessary	This alternative would not preclude or hinder any future remedial activities conducted on the Southern Off-Post Area contaminant plume, if necessary.
Ability to Monitor Effectiveness of Remedy	The effectiveness of the treatment system would be monitored by analysis of samples collected bi-weekly from treatment systems influent and effluent. Aquifer cleanup can be monitored via the groundwater monitoring program.

(continued)

TABLE 13-15
DETAILED ANALYSIS - ALTERNATIVE SOPA-GW3
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SOPA-GW3 CARBON ADSORPTION
Ability to Obtain Approvals and Coordinate with Other Agencies	Obtaining a WPDES permit for the discharge of treated groundwater to the Wisconsin River is not expected to be difficult. The existing IRM facility currently operates under a WPDES permit. Permitting under Wisconsin Shoreline Management Program would be required for effluent discharge pipe construction. Other special permits (e.g., wetland permit) would not be necessary. It is assumed that affected property owners will be cooperative during negotiations for easements.
Availability of Off-site Treatment, Storage, and Disposal Services and Capacity	Facilities which have sufficient capacity for reactivation of spent carbon are available.
Availability of Necessary Equipment and Specialists	Carbon adsorption equipment and expertise is available from several vendors.
Availability of Technology	Carbon adsorption technology for the treatment of groundwater contaminated with chlorinated compounds is available.
Costs	
Capital Cost	
Air Stripping - Groundwater Extraction Scenario 1	$6,447,000
Air Stripping - Groundwater Extraction Scenario 2	$11,501,000
Air Stripping - Groundwater Extraction Scenario 3	22,192,000
Present Worth of Operation and Maintenance Cost	
Air Stripping - Groundwater Extraction Scenario 1	$15,602,000
Air Stripping - Groundwater Extraction Scenario 2	$21,618,000
Air Stripping - Groundwater Extraction Scenario 3	$25,975,000

(continued)

TABLE 13-15
DETAILED ANALYSIS - ALTERNATIVE SOPA-GW3
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

EVALUATION CRITERIA	ALTERNATIVE SOPA-GW3 CARBON ADSORPTION
Net Present Worth Cost	
Air Stripping - Groundwater Extraction Scenario 1	$22,079,000
Air Stripping - Groundwater Extraction Scenario 2	$33,119,000
Air Stripping - Groundwater Extraction Scenario 3	$48,167,000

TABLE 13-16
COMPARATIVE SUMMARY OF GROUNDWATER ALTERNATIVES
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative SOPA-GW1: Minimal Action	Achieves remedial action objectives.	WPALs would be achieved in approximately 66 years (estimated using USEPA batch flushing model) after implementation of the BAAP control wells. Location-specific and action-specific ARARs do not apply.	Interception of the contaminant plume at the southern base boundary would result in eventual decreases in contaminant concentrations and residual risk downgradient (i.e., Southern Off-Post Area) of BAAP.	Contamination is not treated or destroyed; no reduction of toxicity, mobility, or volume of contaminants.	No adverse community or environmental impacts during implementation	No implementability concerns.	Total Present Worth: <u>$2,889,000</u> Capital Cost: $50,000 Annual O&M: $184,000
Alternative SOPA-GW2: Air Stripping	Achieves remedial action objectives.	WPALs would be achieved in approximately 61, 34, or 17 years for Scenarios 1, 2, and 3, respectively (estimated using USEPA batch flushing model) after implementation of BAAP control wells. Capable of achieving WPDES and air permit limits.	This alternative would be implemented to comply with WPALs and secondary drinking water standards. The standards were developed to minimize risk. Also, the contaminant plume would be intercepted at the base boundary; therefore, the magnitude of the residual risk would be minimal.	Removal efficiency greater than 99%. Approximately 24,000 lbs, 48,000 lbs, and 96,000 lbs of spent carbon would be generated every 10 years for groundwater extraction Scenarios 1, 2, and 3, respectively.	No adverse impacts to community. Potentially adverse impacts to environment during construction of extraction system.	No treatment-related implementability concerns. Technologies have been proven full-scale. No problems expected permitting discharge or air emissions. It is assumed that property easements can be easily obtained.	<u>GES 1</u> Total Present Worth: <u>$20,215,000</u> Capital Cost: $6,378,000 Annual O&M: $729,000 <u>GES 2</u> Total Present Worth: <u>$29,583,000</u> Capital Cost: $11,155,000 Annual O&M: $1,138,000 <u>GES 3</u> Total Present Worth: <u>$42,841,000</u> Capital Cost: $21,364,000 Annual O&M: $1,905,000

(continued)

TABLE 13-16
COMPARATIVE SUMMARY OF GROUNDWATER ALTERNATIVES
SOUTHERN OFF-POST AREA GROUNDWATER

FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ALTERNATIVE	OVERALL PROTECTION	COMPLIANCE WITH ARARs	EFFECTIVENESS: LONG-TERM	REDUCTION IN TOXICITY, MOBILITY, AND VOLUME	EFFECTIVENESS: SHORT-TERM	IMPLEMENTABILITY	COST
Alternative SOPA-GW3: Carbon Adsorption	Achieves remedial action objectives.	WPALs would be achieved in approximately 61, 34, or 17 years for Scenarios 1, 2, and 3, respectively (estimated using USEPA batch flushing model) after implementation of BAAP control wells. Capable of achieving WPDES permit limits.	This alternative would be implemented to comply with WPALs and secondary drinking water standards. The standards were developed to minimize risk. Also, the contaminant plume would be intercepted at the base boundary; therefore, the magnitude of the residual risk would be minimal.	Removal efficiency greater than 99%. Approximately 120,000 lbs, 240,000 lbs, and 480,000 lbs of spent carbon would be generated annually for groundwater extraction Scenarios 1, 2, and 3, respectively. Off-site destruction of contaminants.	No adverse impacts to community. Potentially adverse impacts to environment during construction of extraction system.	No treatment-related implementability concerns. Technologies have been proven full-scale. No problems expected permitting discharge. It is assumed that property easements can be easily obtained.	GES 1 Total Present Worth: $22,079,000 Capital Cost: $6,477,000 Annual O&M: $822,000 GES 2 Total Present Worth: $33,119,000 Capital Cost: $11,501,000 Annual O&M: $1,335,000 GES 3 Total Present Worth: $48,167,000 Capital Cost: $22,192,000 Annual O&M: $2,304,000

Notes:

ARARs = Applicable or Relevant and Appropriate Requirements
GES1 = Groundwater extraction Scenario 1
GES2 = Groundwater extraction Scenario 2
GES3 = Groundwater extraction Scenario 3
WPALs = Wisconsin Preventative Action Limits
WPDES = Wisconsin Pollution Discharge Elimination System

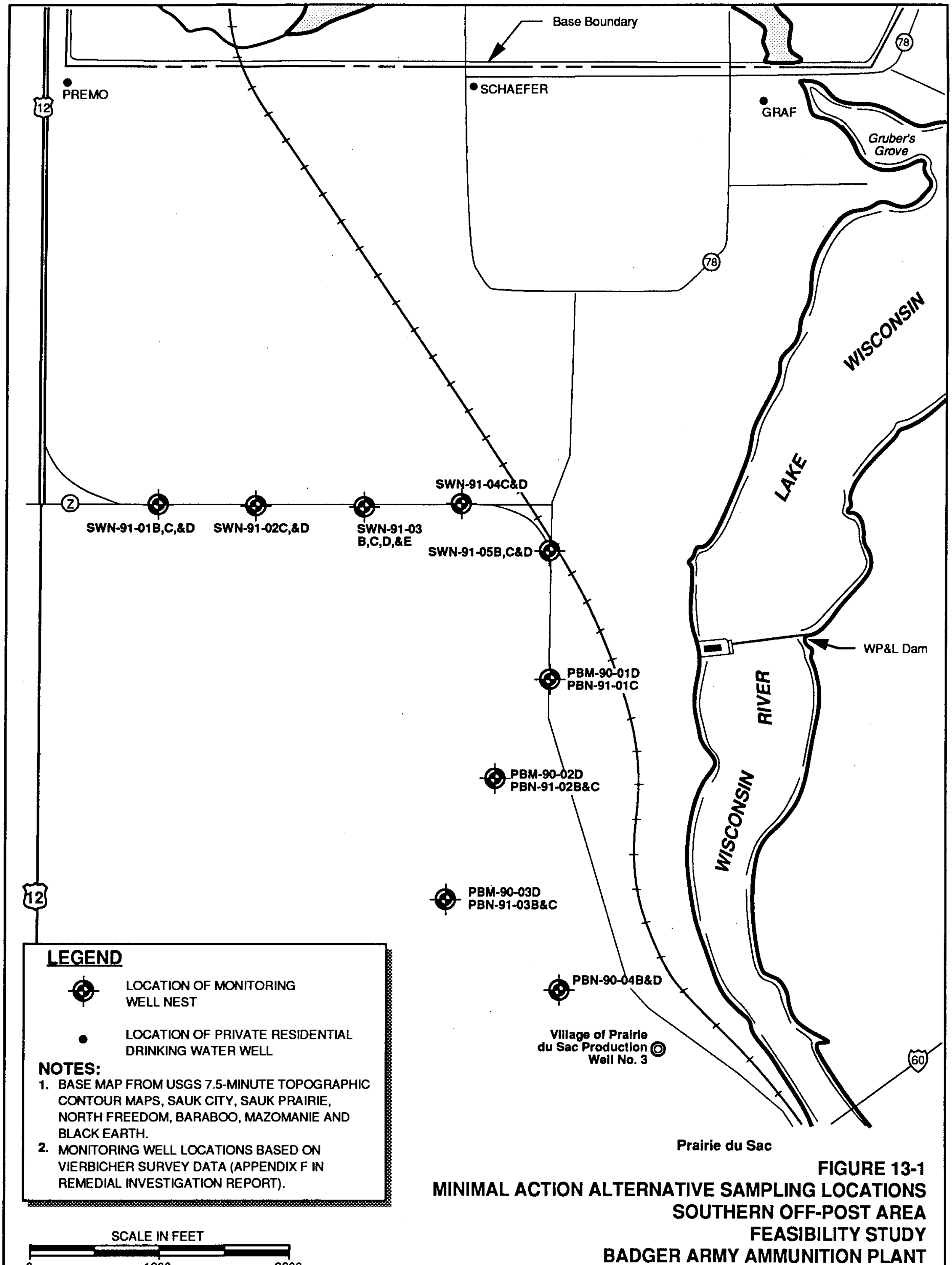

FIGURE 13-1
MINIMAL ACTION ALTERNATIVE SAMPLING LOCATIONS
SOUTHERN OFF-POST AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

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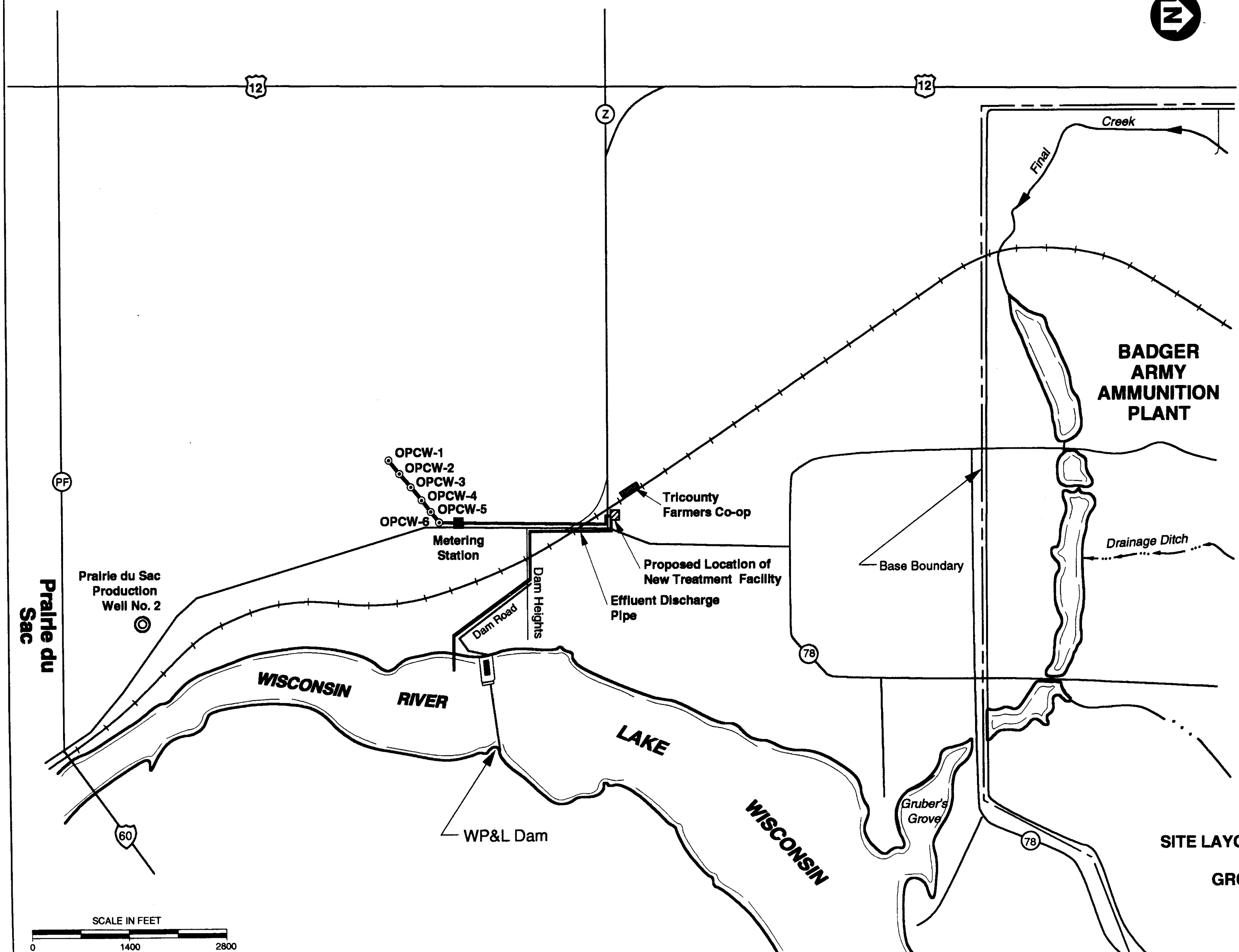

LEGEND

OPCW-1 ⊙ Proposed Extraction Well

— — ——— Base Boundary

NOTES:

1. All proposed extraction well pump rates are 500 gpm.

2. Base map from USGS 7.5-minute topographic contour maps, Sauk City, Sauk Prairie, North Freedom, Baraboo, Mazomanie, and Black Earth.

FIGURE 13-2
SITE LAYOUT FOR GROUNDWATER EXTRACTION, TREATMENT, AND DISCHARGE
GROUNDWATER EXTRACTION SCENARIO 1
SOUTHERN OFF-POST AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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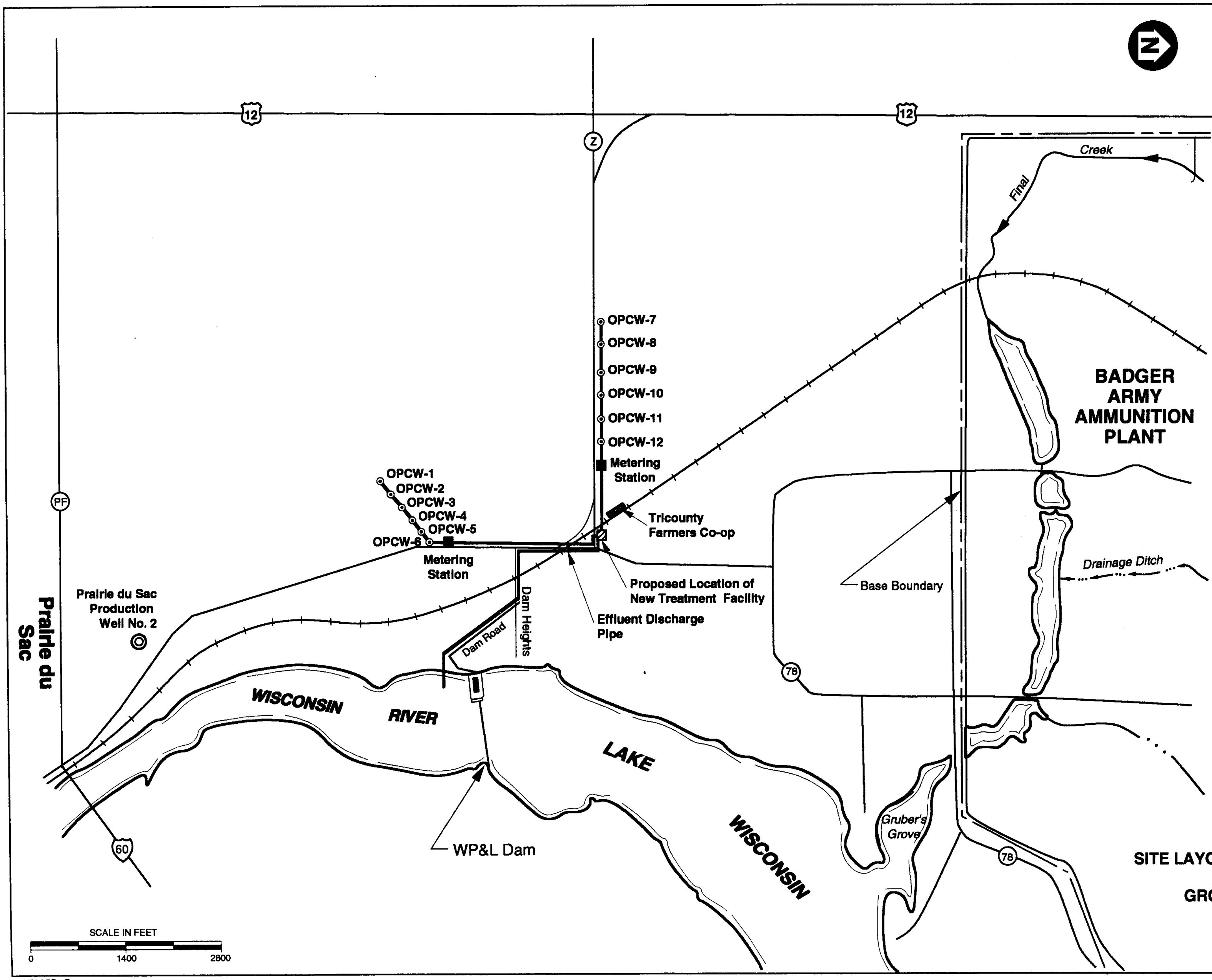

LEGEND

OPCW-1 ⊙ Proposed Extraction Well

— — ——— Base Boundary

NOTES:

1. All proposed extraction well pump rates are 500 gpm.
2. Base map from USGS 7.5-minute topographic contour maps, Sauk City, Sauk Prairie, North Freedom, Baraboo, Mazomanie, and Black Earth.

FIGURE 13-3
SITE LAYOUT FOR GROUNDWATER EXTRACTION, TREATMENT, AND DISCHARGE
GROUNDWATER EXTRACTION SCENARIO 2
SOUTHERN OFF-POST AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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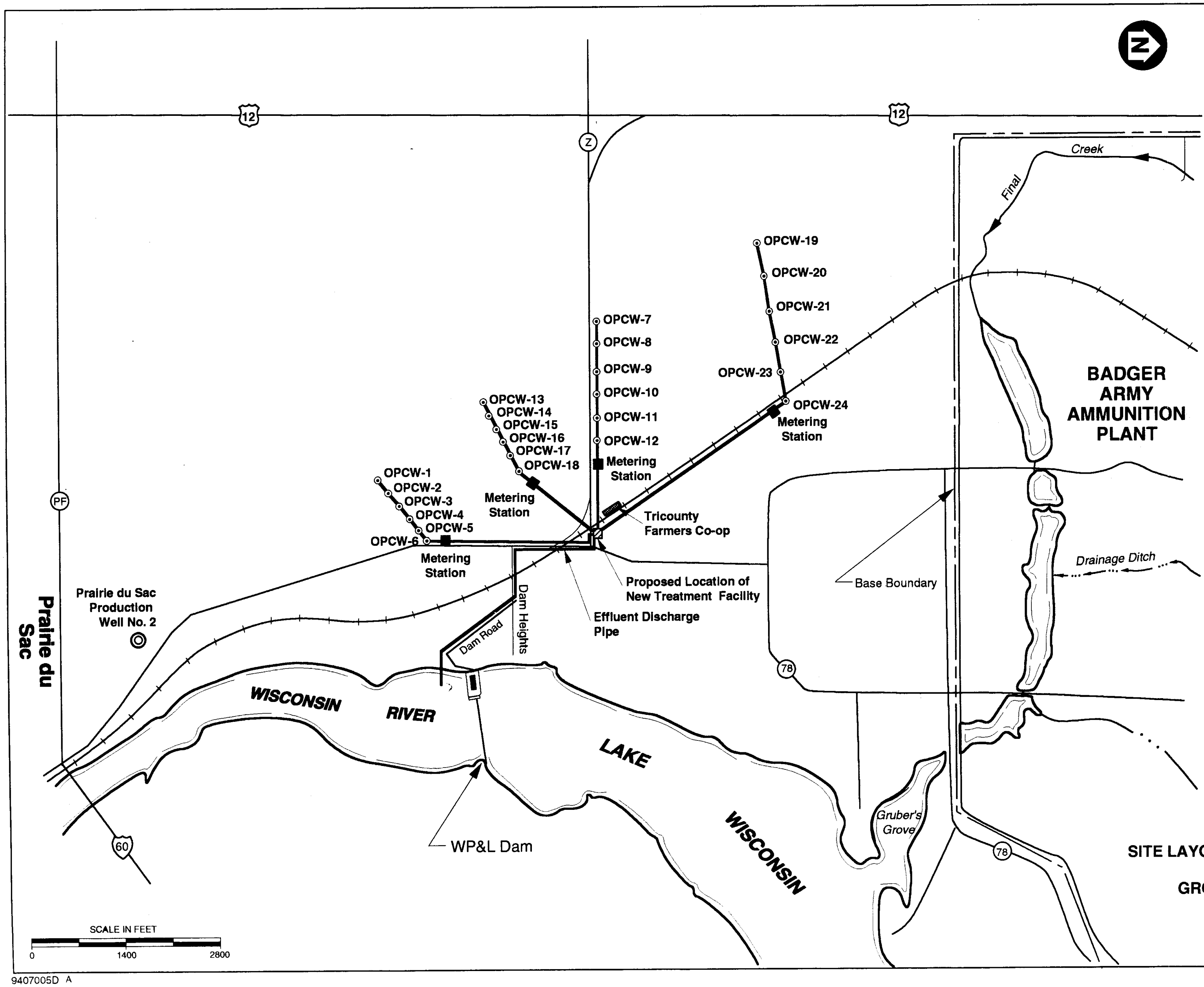

LEGEND

OPCW-1 ⊙ Proposed Extraction Well

— — —— Base Boundary

NOTES:

1. All proposed extraction well pump rates are 500 gpm.
2. Base map from USGS 7.5-minute topographic contour maps, Sauk City, Sauk Prairie, North Freedom, Baraboo, Mazomanie, and Black Earth.

FIGURE 13-4
SITE LAYOUT FOR GROUNDWATER EXTRACTION, TREATMENT, AND DISCHARGE
GROUNDWATER EXTRACTION SCENARIO 3
SOUTHERN OFF-POST AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

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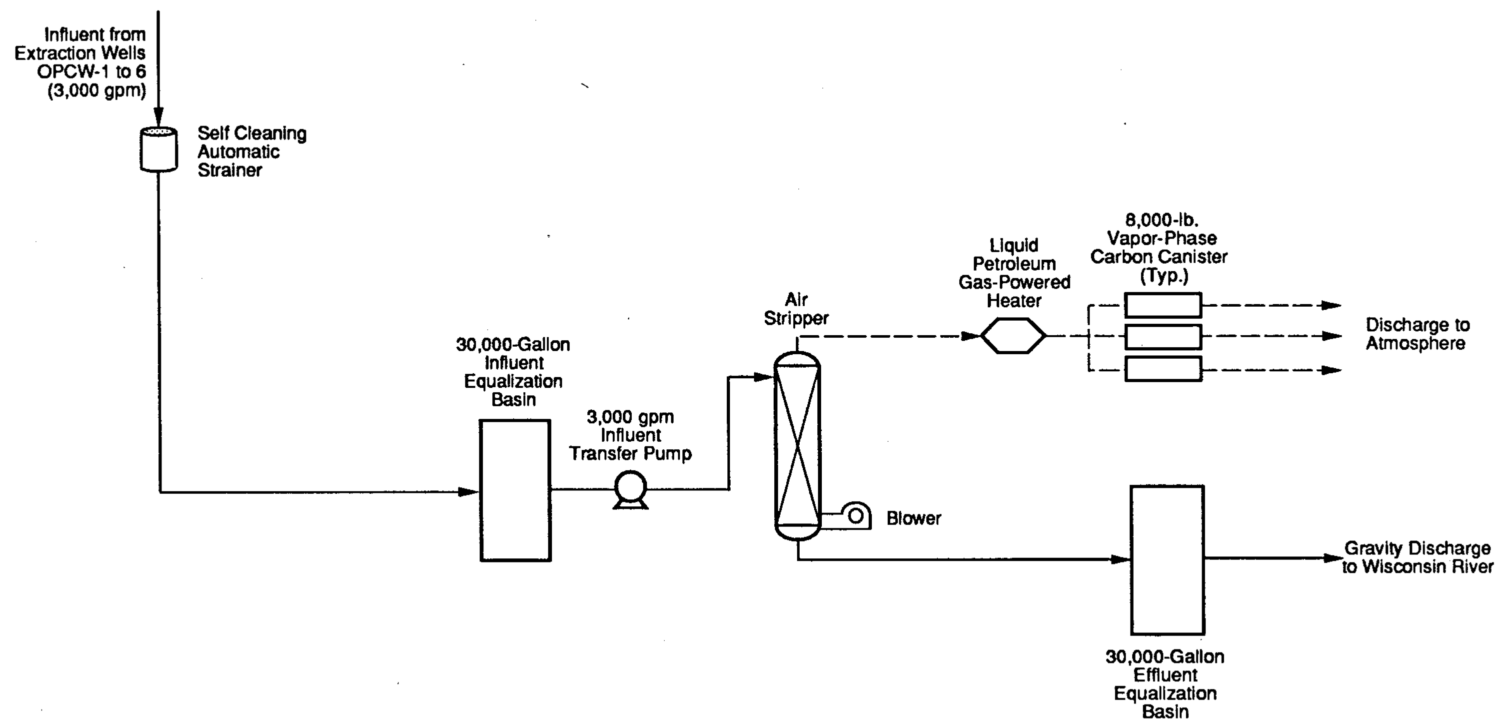

FIGURE 13-5
FLOW DIAGRAM
AIR STRIPPING - GROUNDWATER EXTRACTION SCENARIO 1
SOUTHERN OFF-POST AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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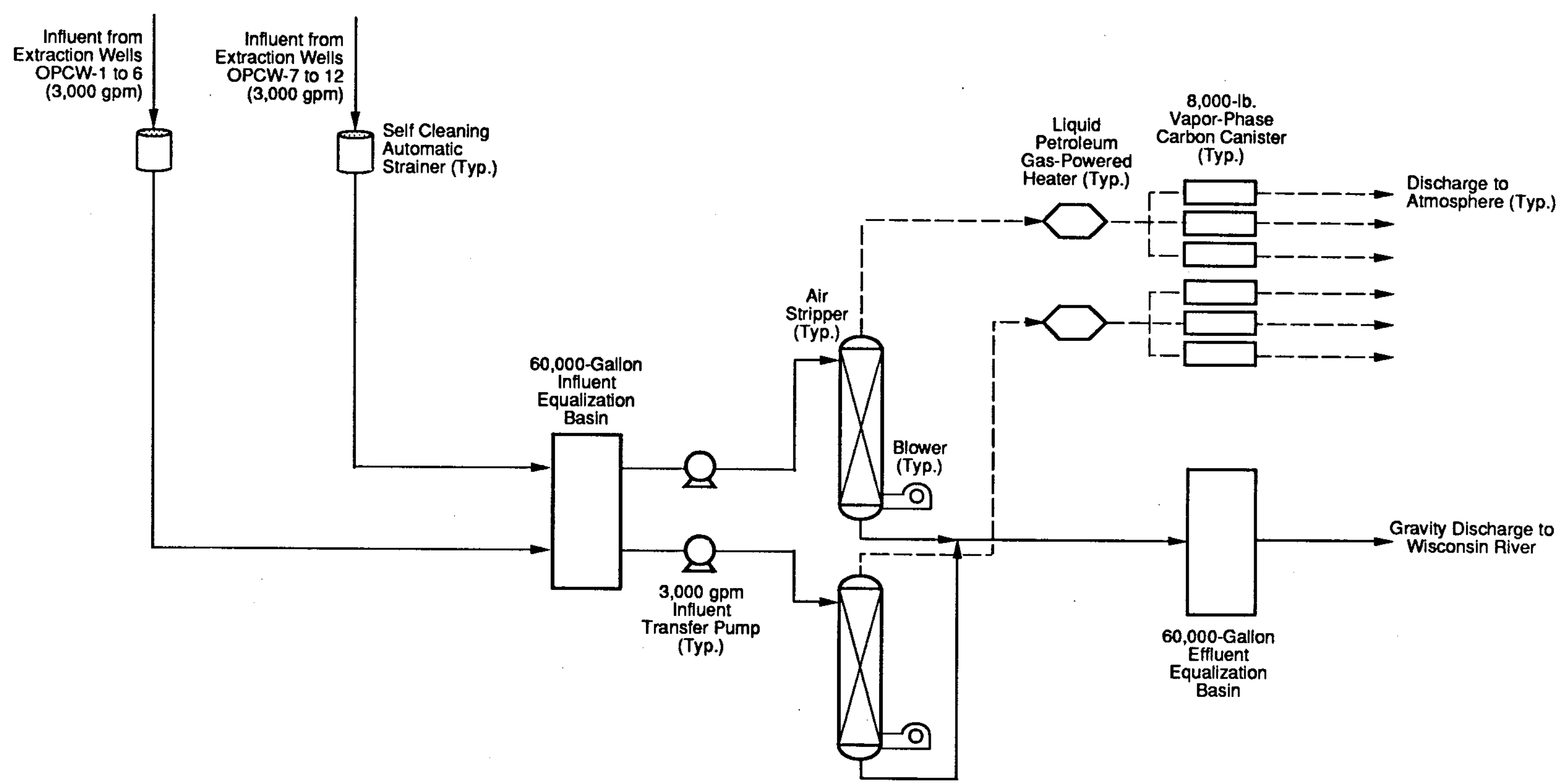

FIGURE 13-6
FLOW DIAGRAM
AIR STRIPPING - GROUNDWATER EXTRACTION SCENARIO 2
SOUTHERN OFF-POST AREA FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

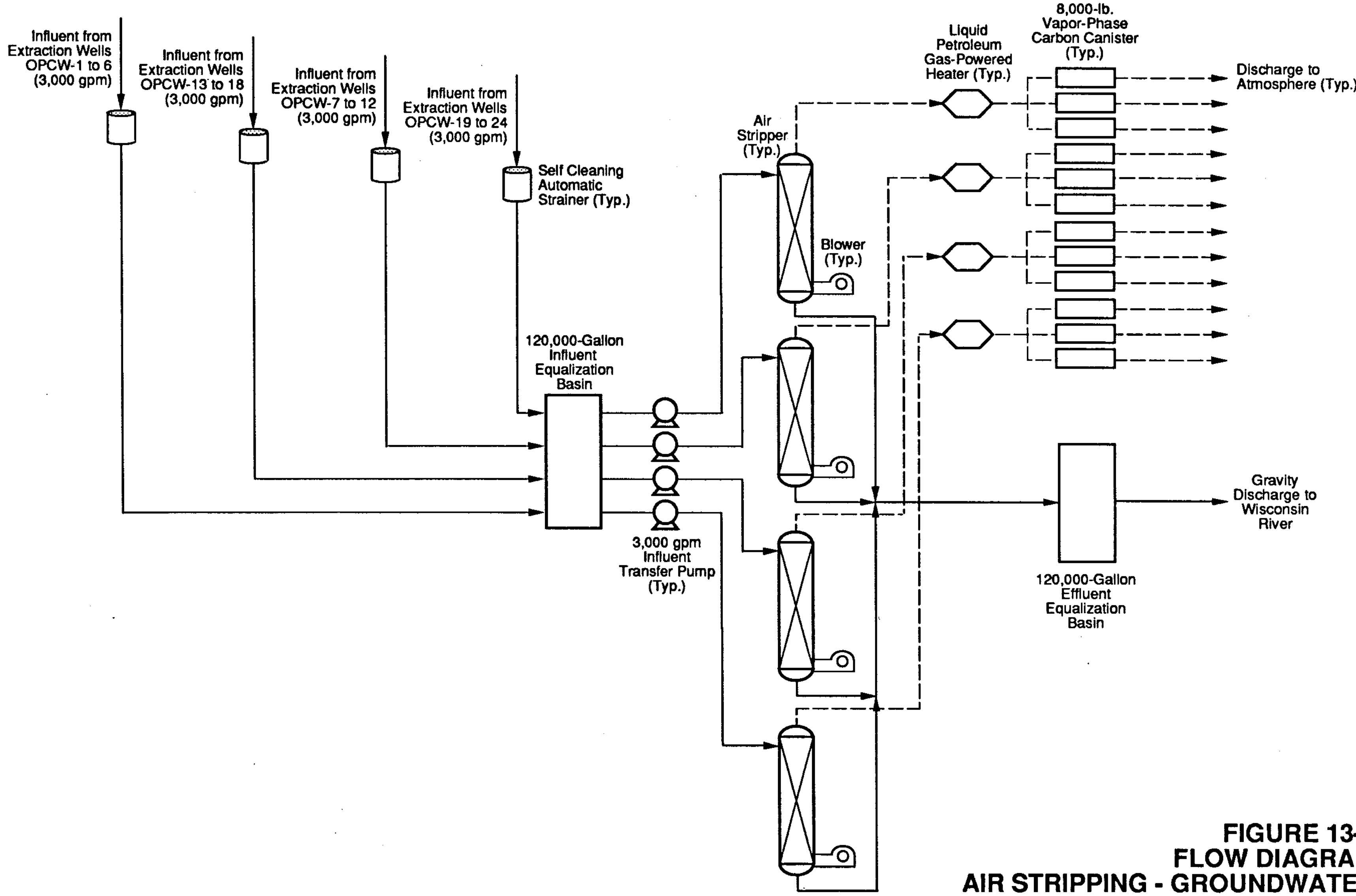

FIGURE 13-7
FLOW DIAGRAM
AIR STRIPPING - GROUNDWATER EXTRACTION SCENARIO 3
SOUTHERN OFF-POST AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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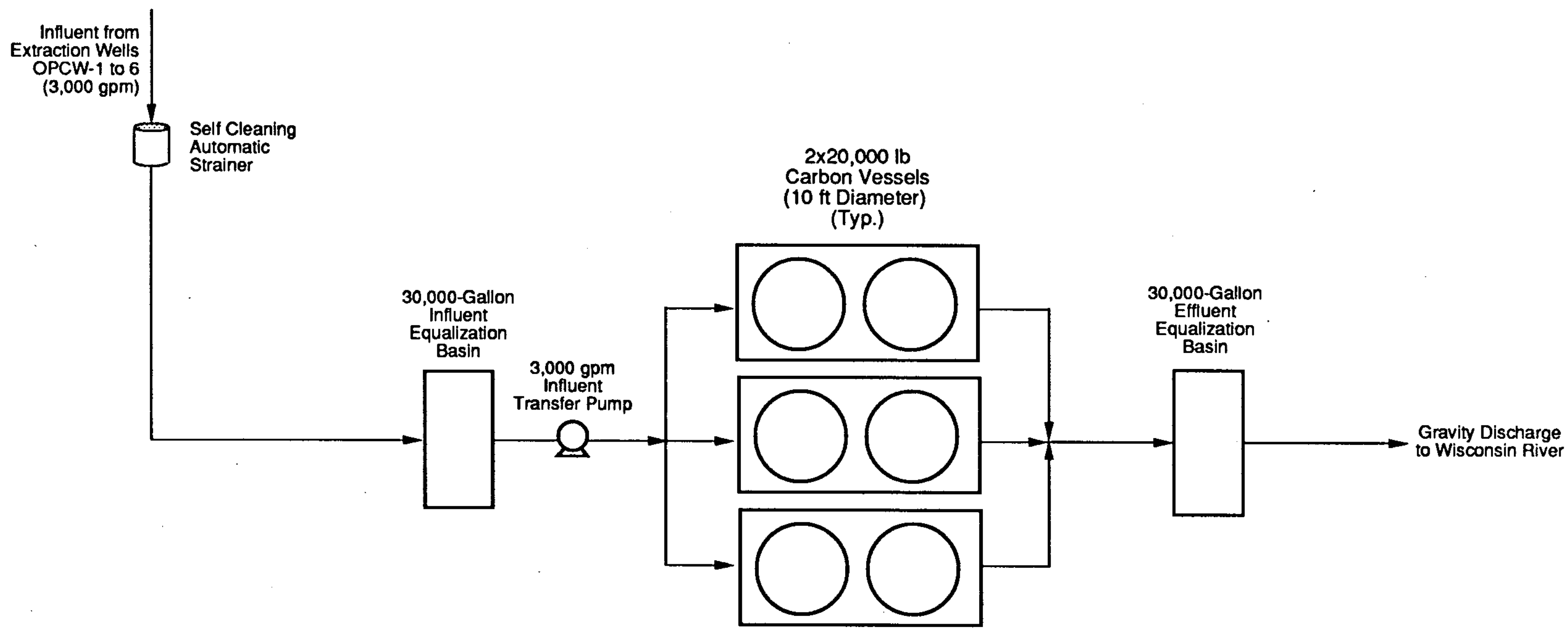

FIGURE13-8
CARBON ADSORPTION - GROUNDWATER EXTRACTION SCENARIO 1
SOUTHERN OFF-POST AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

ABB Environmental Services, Inc.

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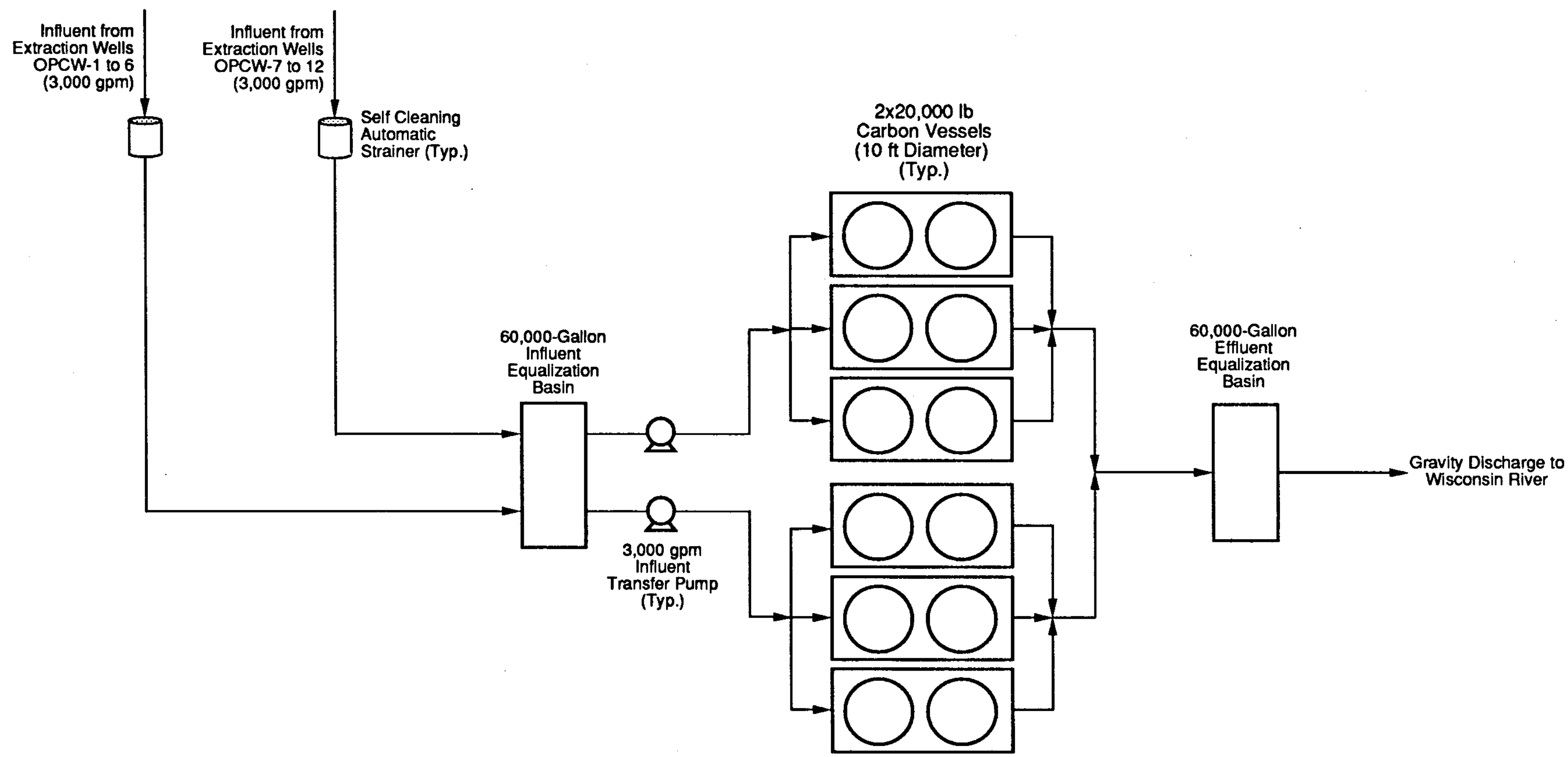

FIGURE 13-9
CARBON ADSORPTION - GROUNDWATER EXTRACTION SCENARIO 2
SOUTHERN OFF-POST AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

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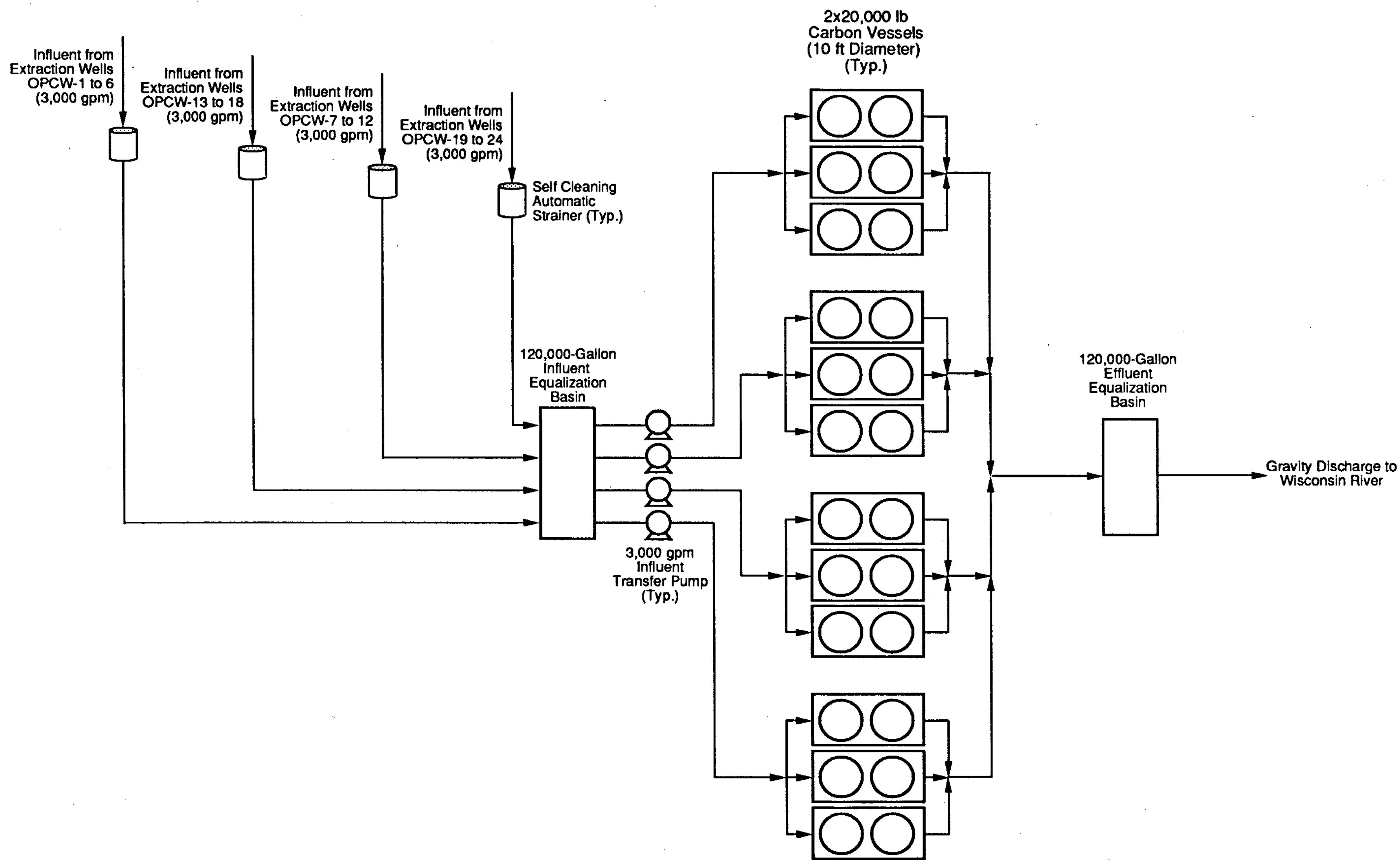

FIGURE 13-10
CARBON ADSORPTION - GROUNDWATER EXTRACTION SCENARIO 3
SOUTHERN OFF-POST AREA
FEASIBILITY STUDY
BADGER ARMY AMMUNITION PLANT

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